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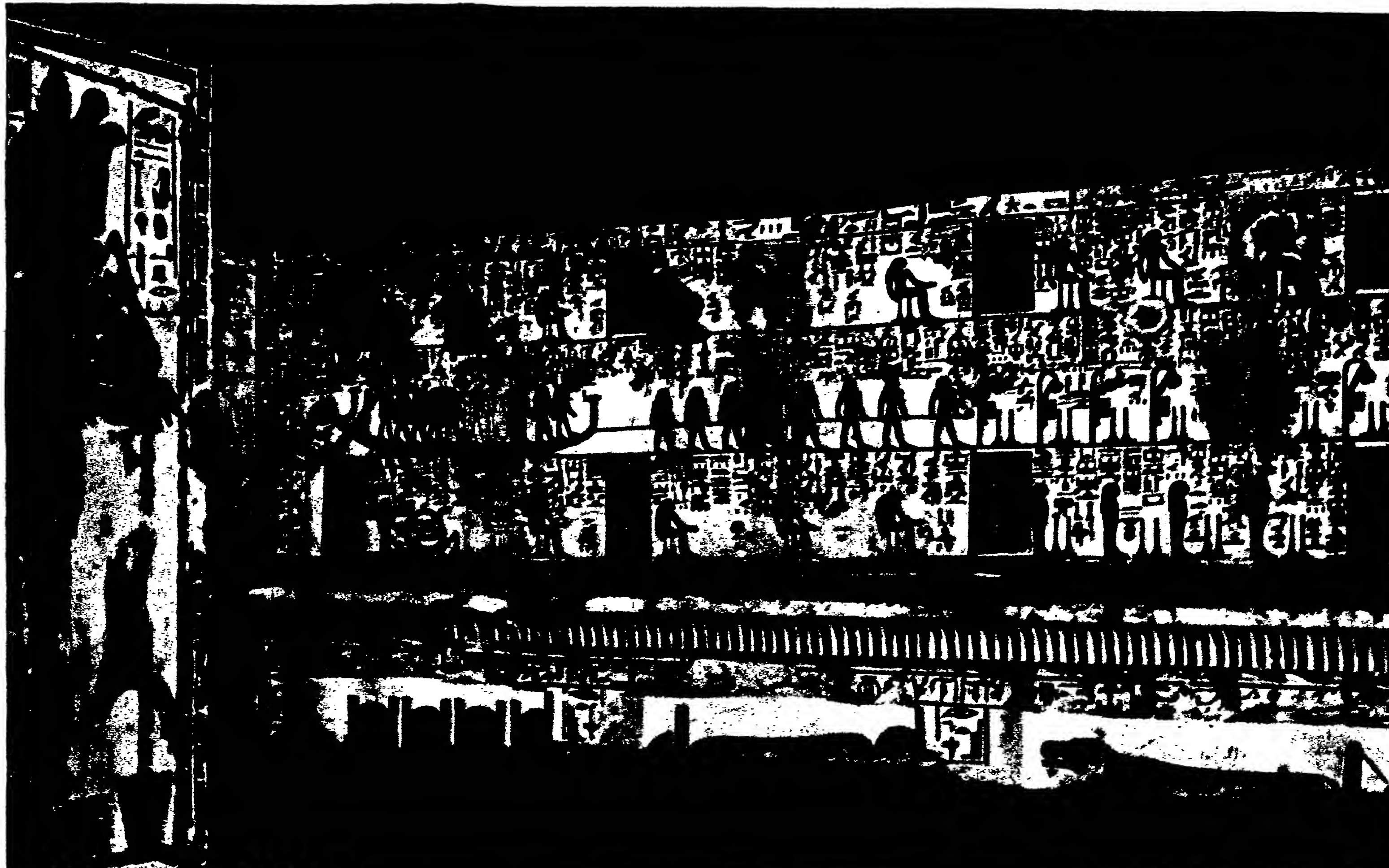

Lichtenstern & Harari

EVERY·DOOR·IS·BARR'D·WITH·GOLD·AND·OPENS·BUT·TO·GOLDEN·KEYS

HARMSWORTH SELF-EDUCATOR

A·GOLDEN·KEY
TO·SUCCESS·IN·LIFE

EDITED·BY·ARTHUR·MEE

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CONTENTS OF THIS VOLUME

INDUSTRIAL CAREERS

CONDITIONS OF EMPLOYMENT IN BRITISH TRADES

THE SELF-EDUCATOR aspires to point its students to the many avenues which lead to careers and to make them fitted for the careers to which it points. Professional careers, commercial careers, careers in the public services—practical information is given about all of these; but the scheme would fall short of completeness if it did not include particulars of the many departments in the vast industrial organisation which makes us the first manufacturing nation in the world. To show the essential conditions of employment in which our millions of producing operatives labour, the details given in the following pages have been compiled. Such an attempt has never before been made.

Industrial Employment. We have striven to indicate in every case the duration and remuneration of apprenticeship and the wages and hours of the operatives, so that parents and guardians may compare the prospects in the many varieties of employment when selecting an occupation for those whose sphere in life they are determining.

The conditions of employment vary very much in different districts. There is nothing approaching the uniformity which is found, for instance, in the municipal or civil services. The details given must be taken as representing the average prevailing generally throughout the country or in the chief centres where the various crafts are followed.

Alphabetical arrangement has not been followed as it would have been really alphabetical disorder. It has been deemed much more convenient to arrange the different industrial occupations in groups according to their nature, and to make the different trades in the several groups ascend from the preliminary to the finishing processes. The groups are considered in the following order:

MINING AND QUARRYING.
BUILDING TRADES.
METAL AND SHIPBUILDING TRADES.
HIDE AND LEATHER TRADES.
TEXTILE AND CLOTHING TRADES.
WOODWORKING TRADES.
GLASS AND EARTHENWARE TRADES.
PAPER AND PRINTING TRADES.
MISCELLANEOUS TRADES.

The Decay of Apprenticeship. Considerable light was thrown upon the decadence of apprenticeship in London by the recent special investigation by the London County Council. It is stated in the Council report that "it is a rare thing to find a young workman who can attack any branch of his trade successfully." It is found that in London the vast majority of managers and foremen are provincials who have secured their training in small provincial shops where they had the chance of receiving intelligent instruction in the several departments. The division of labour not only limits the utility of the workman—it stunts his intelligence. Monotony of occupation, ceaseless attention to a die press or an automatic machine, cannot stimulate thought or exercise the brain; and there is need greater than ever for technical instruction to raise the man from being a food consuming machine.

The SELF-EDUCATOR is a serious attempt to provide the means for improving the workman, who owes to himself and to his future the duty of taking full advantage of his opportunities. Every workman should make himself fitted for the position of foreman, every foreman for the position of manager. The race is to the swift, the battle to the strong, and promotion to those qualified to receive it.

Official Encouragement. The encouragement of artisans is being undertaken as a public duty, and it is certain that the practice will become more general than it is. For instance, at the present time the London County Council offers 30 artisan scholarships—10 of the annual value of £20 each and 20 of the annual value of £10 each—in addition to free tuition. It offers also 100 so-called artisan evening "exhibitions" and 250 evening exhibitions in science and technology—each exhibition carrying a prize of £5 per annum for two years. The nation is awaking to its responsibilities in technical instruction.

MINING AND QUARRYING

Coal Miners. Miners do not technically serve what is understood as an apprenticeship in other trades.

In the Northumberland districts lads are paid at the standard rate of 1s. 1d., plus 15 per cent. per day of 10 hours. Drivers of ponies receive 1s. 4d., plus 15 per cent. per day. Other "off-hand" boys underground receive from 1s. 6d. to 3s. 3d., plus 15 per cent. per day, according to the class of work upon which they are engaged. Standard wages of pony putters are 3s. 2·4d., plus 15 per cent., and of hand putters, 4s. 8·63d., plus 15 per cent. per day. Hewers with long hours (7¼), earn 5s. 2d., plus 15 per cent., and with short hours (6¾), 4s. 9½d., plus 15 per cent. "Above bank" labour is paid at the following rates:

Bankmen on by score	10	hours,	4s. 4·76d.
" " " datal	10	"	3s. 6d.
" " " score	11	"	4s. 10·62d.
" " " datal	11	"	3s. 8·5d

all plus 15 per cent.

Other surface labour is paid at the rate of:

Boys, 1s. 1d. to 2s. 10d., plus 12 per cent.
Men, 2s. 10d. to 3s. 6d., " 12 "

In Scotland, young lads entering the mines at, say, 13 get at present from 2s. to 2s. 6d. per

day for the first year, with 6d. and 1s. per day more for the second year, and 6d. per day further increase the third year.

If they are strongly-built lads they are able to earn four-fifths of a miner's wage after four years in the mine. It is not uncommon for young lads of 17 and 18 years, if muscular, to be earning a man's wage of 5s. 6d. per day. When they have been six years in the mine, and are ordinarily strong young men, they can earn a man's wage. There is nothing to prevent any young man of 17, or even 16, years of age from doing so if he be strong enough and have the natural skill.

There are no technical disabilities as in other trades. Young lads of 13 cannot be kept in the mine more than 54 hours per week, and not more than eight hours on any one day. The standard wage of the Scotch miners for the past three years has been 5s. 6d. per day. This is their minimum wage, arranged jointly by the Conciliation Board between the Scottish mineowners and Scottish miners. They work from eight to nine hours per day. Miners are paid by the piece, or so much per ton. They are not allowed anything for overtime. When men are working on a day's wage to the company, on special occasions they may be allowed time and a quarter, or time and a half, but there is no recognised rule on the subject.

Ironstone Miners. In the Cleveland ironstone mines there are some 7,500 men employed—6,000 of them underground and the remainder on the surface. There is no formal apprenticeship. Boys in somewhat limited numbers begin to work underground at not less than 14 years of age, at a rate of 1s. 1d. per day, or 6s. 6d. per week, and in addition they get a percentage varying according to the price of pig-iron. At the present time the 6s. 6d. becomes, with the percentage, about 8s. per week. As the boys grow older their wages advance, until when they arrive at 21 they make, perhaps, 20s. per week in place of the 8s. with which they start. When the young men take to mining they may make 5s. 9d. to 6s. a day.

A considerable number of men who have not been employed there as boys enter the mines as workmen to break up and fill the ironstone into little waggons or tubs; these men earn about 4s. 6d. a day.

Workmen are generally paid by piece on the quantity of stone mined or filled. Overtime applies in a very limited degree, only a small portion of the workmen being required after the regular hours of the shift.

Shale Miners. There are no apprentices in Scottish shale mining. Men, or strong lads, begin as drawers or fillers, and usually serve two years before being "facemen." Payment is at so much per ton, the amount being determined by the Arbitration Board, and works out at about 6s. per day. Facemen get 6d. to 1s. per day more than drawers. Work is usually for nine hours per day, and being piecework, no extra remuneration is paid for overtime.

Quarrymen. There are several different classes of quarries—those working beds of granite, whinstone, sandstone, limestone, and slate respectively. The chief seat of the granite quarry industry is in Aberdeen, and the conditions there may be considered typical of most quarry work, although they vary somewhat in different districts and in different classes of work. The men can scarcely be described as craftsmen, but rather as labourers and skilled labourers. There is no apprenticeship. The man commences at labourer's wages, and his first work is probably to wield a spade or wheel a barrow. Then, upon a display of aptitude, he is entrusted with drilling work, and is then somewhat of a skilled labourer with a slightly higher wage. The average wages of quarrymen throughout the country are from 4½d. to 6d. per hour. In slate quarrying apprenticeship is not strict, but six years is the rule. It depends on the aptitude of the youth. Apprentices are usually the sons of slate quarrymen; but this is not a condition, and there is no restriction as to numbers. Apprentices have an eight hours' working day. They are put upon piecework from the start, and earnings depend on skill and speed. All work is by contract; but to obviate a contract not paying, the men are guaranteed a minimum wage, which varies from 25s. to 30s. per week, according to district. The day has 10 working hours, but in winter is shorter, lasting from dawn to dusk. The minimum wage applies to both winter and summer work.

BUILDING TRADES

Masons and Stonecutters. Rules of employment vary considerably in different districts. Where workmen's unions are well constituted and well directed, the conditions are generally much more favourable to the operatives than elsewhere. In most districts the number of apprentices employed bears some relation to the number of workmen. It is often restricted by the workmen to a maximum of one apprentice for every two workmen employed by the firms on the year's average.

In England, apprentices must be 14 years old; they serve seven years, and usually receive wages as follow:

First Year	1d. per hour.
Second Year	2d. ,,
Third Year	3d. ,,
Fourth Year	3½d. ,,
Fifth Year	4d. ,,
Sixth Year	5d. ,,
Seventh Year	6d. ,,

Payment by time is usual, and the average wages are 8d. per hour, except for outside work in winter, when the rate is ½d. higher. Overtime up to 10 p.m. is paid at one and a quarter rate, and from 10 p.m. to 6 a.m. double time. Men required to work more than four miles from the shop are often paid 1d. per hour extra as "lodging money," with fares in addition. Hours of shop work are usually 54 per week.

In Scotland, apprentices usually serve five years if they begin younger than 17 years old,

and for four years if older than 17. No apprentices taken after the age of 25 years. Usually, wages begin at 5s. or 6s. a week, and rise to 12s. or 15s. Hours worked are nine per day in summer, and eight in winter. Wages vary from 7d. to 11d. per hour, according to district. Men supply their own tools. Overtime is usually at one and a quarter rate, and sometimes at one and a half rate, irrespective of its duration.

In some places—Aberdeen, for instance—there is a large *monumental* trade. Conditions of apprenticeship are similar to those in the building trade already given. Hours worked—nine per weekday, except Saturday—are the same in summer and winter. Wages are less than those of masons, the respective rates in Aberdeen being 8d. and 7d. per hour, but the employers supply and uphold tools.

Settmakers have no uniform conditions of work. Apprenticeship is general—four years—but there is no regular rate of wages, which depend upon the age and skill of the youth. Workmen are paid by piece, and earn good wages, anything from 40s. to 80s. per week. No regular hours of working.

In Ireland, the Stonecutters' Union insists that apprentice stonecutters must be the sons of stonecutters, except in unusual circumstances. Usual apprenticeship lasts seven years, but there are no indentures, and it is common for a lad with three or four years' experience to demand journeyman's wages and, in the event of refusal, to seek another situation. Standard wages of provincial workmen are 30s. for 57 hours 'work in summer, and 30s. per week in winter from dawn to dusk. In the cities and large towns wages are higher—Dublin, 36s. for 54 hours (8d. per hour); Cork, 34s. 6d., Limerick, 33s. Overtime is discouraged by the men, but is paid one and a half rate till midnight, and double rate from midnight till 6 a.m. In Belfast, where the men are not attached to the Stonecutters' Union of Ireland, the wages are 8½d. per week of 51 hours, and apprentices are permitted at the rate of 1 to 10 employees.

Marble and Slate Masons. The number of apprentices is restricted. Three are usually considered sufficient for a shop of, say, forty men. Apprenticeship lasts five years; wages begin at 5s. per week and rise by 2s. per week annually. Some of the best London shops require a £20 premium from apprentices. Many workmen urge the need for a longer apprenticeship, as it is held that five years is too brief to turn out competent men, and journeymen who have just finished a five years' apprenticeship frequently accept 3d. an hour under workmen's standard wage. Present wage in London is 10½d. per hour for 48½ hours per week, with one and a quarter rate for overtime up to two hours, one and a half rate beyond two hours till 10 p.m., and double rate for night work.

Bricklayers. System of apprenticeship is becoming most strict and more generally recognised. Time usually served is seven years, although five and six years are not unknown. Apprentice wages differ. Average is probably 5s. per week for the first year, with an annual increase of 2s. 6d. per week. Wages and hours of labour differ in different districts. The following are the conditions in representative towns:

	Hours of Work per week. Summer.	Winter.	Current Wages in pence per hour.
Manchester	54½	47	10
Birmingham ..	54	45	9½
Leeds	50	45	9½
London	50	44½	10½
Sheffield	49½	44	9½
Liverpool ..	49½	47	9½
Londonderry ..	56½	daylight	7
Newcastle-on-Tyne	50	44	9½

Overtime is generally paid at one and a quarter rate for first three hours, and one and a half rate beyond that time and on Saturday afternoon, while Sunday work is paid at double ordinary rate. Winter work is hard, and in time of frost ceases altogether. During severe winters workmen may be idle for as long as 12 weeks.

Slaters and Tilers. Apprentices must be legally bound at or before attaining 16 years, and must serve until the age of 21. There is one apprentice to every three workmen, the maximum number permitted by the workmen's society. Average apprenticeship wages are 8s., 9s., 10s., 12s. and 14s. per week for the five years. Apprenticeship is all but universal. Standard wages differ widely in different districts, and the society aims at securing in each district uniformity of conditions and wages. Average wage is probably 9d. per hour, the highest rate being 10d. per hour. The 10d. rate prevails in London and in the North of England. The lowest rate is found in Lincoln and Lowestoft, with only 6½d. per hour. In Dublin and Belfast the 9d. rate is paid. In Scotland slightly lower wages prevail and about 8½d. per hour is the average. The hours of labour vary in different districts. They are fewest in the North of England—namely, 50 hours per week during 40 weeks in the year; 42 hours per week for three weeks before and three weeks after Christmas; and 44½ hours for three weeks before and three weeks after the 42-hour weeks. In other districts the hours are longer and reach the maximum of ten hours per day in the London district. In all cases hours are shorter in winter. No extra rate is paid for overtime in England, except in exceptional cases, as for instance, when the roof of a spinning mill has to be repaired during the night, on Saturday afternoons, or on Sundays or holidays, while the machinery is silent.

In Scotland the conditions are similar to those in England. Apprenticeship is general, starting at 8s. per week and rising to 15s. Hours, 45 in depth of winter to 51 per week in summer. Journeyman's wages 8d. to 9d. per hour. Overtime 25 per cent. above usual rates from 5 to 9 p.m., 50 per cent. higher after 9 p.m., and double on Sundays.

Carpenters and Joiners. Machinery and the growth of departmentalism have wrought great changes in the trade. Formerly, five years' apprenticeship and often a heavy

premium were required from lads entering the trade. Present conditions differ widely in different districts, but the following may be considered representative of the average. A boy works for three or four years, beginning at from 3s. a week to 1d. per hour, and rising annually by ½d. per hour. As an improver he may receive 5d. or 6d. per hour. Large shops, where departmentalism prevails, do not give so good a training as smaller shops. Apprenticeship, where it is still the rule, lasts five to six years. Hours, 48 to 60 per week. Wages, 10½d. per hour in London, varying in country districts to 22s. per week in outlying parts. Overtime, usually 25 per cent. higher for first two hours; 50 per cent. higher for next two hours, and double for all night and Sunday work. In some districts no extra rate is paid.

Painters. Conditions vary considerably. Apprenticeship, often six years, beginning 3s. to 5s., and rising from 12s. to 16s. In London apprenticeship is almost extinct, and where it still prevails it seldom lasts longer than one year. Workmen's wages are from 5½d. an hour in outlying districts to 9d. and 10d. an hour in cities where the trade is organised. Hours worked vary from 51 to 56 per week. Overtime wage rate usually time and a quarter or time and a half, but in London it is unusual to pay any higher rate for overtime. Ship painters work 54 hours. The position of a working painter is not particularly desirable. Three-quarters of the total number have no employment for more than nine or ten months in the year.

Plumbers. Apprenticeship was formerly for seven years but now five years is common. Premiums of from £5 to £50 sometimes demanded by good firms. Wages begin at 2s. 6d. to 5s. per week and rise to from 15s. to 20s. during the last year. Wages for workmen vary from 6d. per hour in some country districts to 11d. per hour in London. The London hours are 47 per week, but in the provinces they are sometimes as many as 56½. Overtime is paid at one and a quarter rates, and when prolonged at one and a half and double rates.

Gasfitters. The conditions generally are the same as those for plumbers. Gasfitters' work is inside to a greater extent than plumbers' work, hence time is not lost by the short day during the winter months as it is in the plumbing trade.

Plasterers. Apprenticeship, five years, at 5s. per week, rising 2s. each year. Usual rule is one apprentice to two workmen. Workmen, 51 hours per week at 7½d. to 9½d. per hour. Varies in different districts. Overtime, time and a half.

Glaziers. Apprenticeship not uniform, but usual term is five years. Indentured apprentices usually begin at 6s. a week, advancing 2s. per week annually. Unindentured apprentices often earn more than indentured apprentices when they have been some time at the trade. Workmen's hours and wages are not uniform, but the average is about 8½d. an hour in larger towns for a 51-hours' week. Overtime is paid at one and a quarter rates.

METAL AND SHIPBUILDING TRADES

Steel Smelting. On account of the nature of the work, boys cannot be employed in steel smelting, and there are no apprentices. New hands are described as helpers, and workmen are graded into first, second, and third hands. A man must work for 12 months as third hand before promotion to second hand, and two years as second hand before rising to the dignity of first hand. Workmen are generally paid per ton of metal produced. This differs so, that no generally applicable wage rate can be stated. In some districts where specialities are worked, day wages are paid, ranging from 10s. 6d. to 20s. per day for first hand, from 7s. 6d. to 15s. per day for second hand, and from 5s. 9d. to 10s. per day for third hand. Where men are paid on tonnage, nothing extra is paid for overtime. On day wages, men who work after noon on Saturday are paid time and half, and on Sunday from one and a quarter to double rates. Overtime is exceptional. The high wages are quite justified by the great physical exertion necessary and by the wear and tear of clothing. The work is continuous, and is carried on by 12-hour shifts.

Rolling Mill Workers. There is no apprenticeship here. There are several positions which boys can fill, and they are promoted from one to another as they gain experience and show ability. Aptitude in technical knowledge secures promotion. Generally speaking, the rules that apply to steel smelting prevail in the rolling mills. Work ceases at 2 p.m. on Saturday and overtime is worked only in emergencies.

Tinplate Mill Workers. The information given under Rolling Mill Workers applies also to tinplate mill workers, except that eight-hour and not 12-hour shifts are the rule.

Chainmakers. Youths who enter the chainmaking trade are usually the sons of workers. No apprenticeship system proper; boys begin by blowing the bellows in outshops, then go on to form the links, rising to the manufacture of cheap untested chains, and finally becoming skilled workmen. All work is by piece, and the workmen may earn anything between 20s. and 40s. per week. Hours are irregular, but no work is done after 5.30 p.m. in factories. Cradley Heath is the centre of the chainmaking industry. Modern practice tends to introduce machine-forged chains, and the hand forger will find smaller scope for his skill.

Anchorsmiths. This trade is similar in its conditions to that of chainmakers, and finds its centre in the same locality.

Wire and Tube Drawers. No recognised apprenticeship. Boys begin at from 14 to 18 years old, and are paid according to merit. Workmen earn 24s. to 50s. per week, according to class of work, and their working week has 54 hours.

Shipbuilding. Apprenticeship usual, and must begin between the ages of 16 and 19. Boys entering before 18 serve five years; after 18, until they are 23 years old. Apprentices are

selected from the ranks of the boys taken on as "platers' markers" and "rivet boys." The minimum rates of pay for apprentice smiths, platers, and caulkers, are 6s., 7s., 8s., 10s., and 12s. per week during the respective five years. Apprentice riveters earn 7s., 8s., 10s., 12s., and 14s. per week. The standard wages of workmen differ throughout the kingdom. Day wages for smiths and platers range from 36s. to 45s. per week, for riveters and caulkers from 32s. to 38s. per week, and holders-up from 26s. to 32s. per week. The majority of the work, however, is on piece wages, which amount to from 50 to 100 per cent. above the figures given. Repair work is paid at 6d. to 1s. per day in excess of the rates for new work.

Barge Builders. Apprenticeship of seven years enforced. Usual wages of 6s., rising to 13s. per week. The union rate of wages for barge building on the Thames is 10d. per hour, and 11½d. per hour for overtime. Hours of work, 54 per week.

Boiler Making. The conditions are similar to those given under Shipbuilders, but apprenticeship is usually seven years, and the standard wages for piecework boilermakers are generally 25 to 50 per cent. higher than day wages.

Blacksmiths. In the North of England unindentured apprenticeship of five or six years is usual. Boys usually start in the smith's shop as hammer drivers at the age of 14 years, and after 12 to 18 months' experience, they usually begin to act as strikers. After 12 months in the latter capacity they are promoted to a fire, and work as apprentice smiths up to 21 years of age.

The wage when they begin work as hammer drivers is usually 5s. per week, and they are advanced by easy stages of 1s., 1s. 6d., and 2s. per week per annum until in their last year of apprenticeship they are receiving 15s. or 17s. per week. The standard rate of wages for blacksmiths is from 34s. to 38s. per week, according to the district in which they are employed.

Hours of labour also vary ; in some firms they work 48 hours, other firms 50, other firms 53, and others 54 hours per week.

Blacksmiths usually work piecework, and earn a bonus over their weekly wage, varying from 25 to 33 per cent. There is usually an allowance paid for overtime ; this again varies according to various districts, but, as an example, in the Manchester district they are paid 25 per cent. over the ordinary wage for the first two hours, 50 per cent. over for the next two hours, and 100 per cent. for all time worked after that. These rates apply also for Saturday afternoons. For Sundays, Christmas Days and Good Fridays they are paid 100 per cent. over the ordinary rate. In other districts overtime is paid for at the rate of 25 per cent. over the ordinary rate for the first two hours, and 50 per cent. afterwards.

Smiths in the coach and wheelwright trades work longer than in other branches, usually 56 hours, and earn less, with no higher rate for overtime.

In London boys begin as strikers at the age of 14 or 15, earning 10s. a week, and rising to 29s. 3d. at the age of 20. The best strikers are promoted to be smiths between 20 and 30 years of age, and after working as such for varying periods (one to four years) at less than standard wages, rise to the full remuneration, usually 40s. for 54 hours work. The craft of the smith is declining in London and increasing in the provinces.

Farriers. In the provinces apprenticeship is common ; but in London it is almost unknown and the ranks of the trade are recruited from the provincial inflow. Hours vary from 52 to 61 per week, and though there is not much overtime during the week, a certain amount of Sunday work is often performed. In London the wages of doormen are from 25s. to 34s. per week, averaging 31s., and of firemen 33s. to 42s., averaging 37s. In the provinces the wages may be much lower, sometimes 20 per cent. less than the figures mentioned, the lowest rates ruling in the smallest towns and villages. The work is exhausting, and especially when the hours are irregular, as they frequently are, they tell upon the individual.

Ironfounders. Apart from the iron-moulders in engineering shops, there seems to be no general system of apprenticeship in ironfounders. Lads—15 or 16 years old—begin work at about 5s. a week and learn the trade as they can, receiving higher wages as they are able to do better work. The recognised proportion is one boy to three men, but the proportion of boys is usually less than this. The wages of moulders in London are 38s. and sometimes 40s. per week ; but in large provincial centres this is reduced to 32s. and 34s. Pattern-makers earn 40s. per week, but in non-union shops sometimes only 36s. or 38s. Overtime, of which there is a good deal, is paid for at one and a quarter rate, rising to double rate when of excessive duration.

Typefounders. Apprentices almost unknown. Beginners must be at least 18 years of age, and usually work for five years, earning 18s. during the first year, and rising to 36s. Hours of work are 54 per week. Payment for both day and piece work is by complicated rules, of which the following is a sample: Casting (two machines), £1 16s. ; casting (one machine), £1 13s. 9d. ; dressing, £1 16s. ; rubbing, £1 9s. 6d. ; kerning, £1 13s. ; warehousemen, £1 16s. ; mould-makers, £2 5s. ; justifiers, £2 ; metal making, £1 14s. ; lead casting, £1 13 ; porters, £1 7s. ; furniture and quotations, £1 13 ; mould setters, £1 18s. ; sanspareil casting, £1 13s. Overtime seldom required. Payment, one and a quarter rates for first two hours, one and a half rates for second two hours, after which, and also on Sundays and Bank Holidays, double rates are paid.

Core Makers. Apprenticeship usually five to seven years, beginning at 4s. per week, and rising to 14s. or 16s. during the last year. Wages are usually 32s. to 38s. for workmen in organised districts, but less where the men are not united. The hours of work are 53 per week. Sometimes no extra rate is paid for overtime, which may,

in other places, be remunerated at one and a quarter or one and a half rates.

Stove Makers. In the Rotherham district the apprenticeship system is becoming less common. Where it exists, seven years is the rule, from 14 to 21 years of age. Wages begin at 4s., rising to 11s. per week. Sometimes, at 17 years old, the youth is put on piecework, and paid 70 per cent. of usual workman's rates. Standard wages in the different departments vary, and range from 30s. to 40s. per week. Overtime is sometimes at one and a quarter and sometimes at one and a half rate.

Bedstead Makers. Apprenticeship uncommon. Boys enter the works at about 15, at an average wage of 8s. per week, rising by successive increases to 15s. at the age of 18. From 18 to 21 the youth usually receives a bonus of 15 per cent. on salary in addition to annual increases. At 21 he earns 23s., plus the bonus. The minimum rate for day labour is 6d. per hour, plus a 15 per cent. bonus, and a maximum 10d. per hour with a bonus. The worker on the piece system may earn anything between 35s. and 80s. per week, plus a similar bonus. The greater part of the trade is in piecework. The hours worked vary from 52 to 54 per week.

Tank Makers. Machinery has changed the conditions of this trade, and fewer men are entering it. There is no apprenticeship. Formerly, workmen riveters could earn 50s. to 80s. per week, and "holders-up" two-thirds of that amount, but such men are now few, as the machine has taken their place, and remuneration is now on a scale a little above that of an intelligent labourer.

Engineers — General and Textile. Apprenticeship usual from about 14 to 21 years of age; earnings 5s., 6s., 7s., 9s., 11s., 13s., and 15s. per week during the seven years. Rates vary very much with the demand for labour in the districts; sometimes as low as 2s. 6d. is paid during first year. Then for two and a half years the ex-apprentice may be an improver, beginning at 24s. a week and receiving an increase of 2s. per week every six months until he attains the workman's standard wage, which is as follows, for the various classes in the Midlands:

Textile Fitters and Turners	34s.	per week
Tool ,, ,,	36s.	,,
Grinders (light work) ..	36s.	,,
,, (heavy work) ..	38s.	,,
Smiths	36s.	,,
Moulders	32s. and 34s.	,,
Pattern Makers	40s.	,,

In other districts the rates may vary slightly.

Pieceworkers, who are common, earn from 20 to 25 per cent. above these rates. Hours are 53 per week. Overtime among men covered by the Amalgamated Society of Engineers is paid one and a quarter rate for first two hours, one and a half rate for second two hours, and double time thereafter. Machine and plate moulders, planers, millers, drillers, and labourers receive no higher rate for overtime.

Engineers' Tool Makers. Indentured apprenticeship quite dead. Boys begin at about 14, and receive 6s. to 10s. a week, according to age and ability, rising to 14s. to 18s. at 21 years of age. Day wages of workmen, 28s. to 42s. per week of 54 hours. Piecework prevails, and higher wages are thereby earned. Overtime follows the practice of engineers.

Edge Tool Makers. Edge tool and hoe makers require assistant strikers who develop into skilled workmen. Lads begin heating at about 15 years of age, and when about 19, are usually made strikers. After some years—about the age of 25 or 26—the striker gets a fire and develops into a skilled workman. Strikers earn 26s. or 28s. a week, and workmen 40s. to 45s., all on piecework. Day wages for odd work are 66s. a week in Birmingham for workman and striker together. Hours are 50 per week, and nothing extra is paid for overtime.

File Makers. No apprenticeship proper. A boy begins heating at about 14 years, receiving 6s. per week, with an advance of 1s. per week per annum until 17 years old, when he will probably receive 16s. per week, and a further 2s. advance each year until he attains 21 years, when he ought to be able to earn a qualified workman's wage of 40s. to 50s. Usual hours are 54 per week.

Plane Makers. An apprenticeship of seven years is usual in England and of five years in Scotland. The youth serves half this period under a journeyman, beginning at 5s. per week, and rising by 1s. per annum. During the second half he is put on piecework and receives two-thirds of the ordinary workman's wages. Plane makers are paid entirely by piece, and a fair artisan averages 34s. for week of 54 hours. Overtime is seldom required, and is paid as ordinary work.

Razor Forgers. All workers are on piecework, and a boy entering the trade becomes engaged to the workman and not to the employer. No boy is admitted to the trade except the son or the stepson of a worker, and he must be not less than 14 years of age. There is no recognised rule as to paying apprentices, as, under the rules enforced by the trade union, the whole apprenticeship system is practically boys helping their fathers. Workmen earn good wages. A man of fair ability has no difficulty in making 50s. a week.

Gun Makers. Apprenticeship much less common than formerly, but where it prevails, seven years is the usual time, and 7s. the commencing wage, rising to 14s. For workmen, the day wage is usually 1s. per hour, but where piecework is the rule, more money, varying in accordance with the ability of the workman, may be earned. There are no uniform hours of work throughout the several departments.

Lock Makers. Apprenticeship used to be general, but it is now obsolete. All locks are now made by piecework, and an expert and expeditious worker may earn twice as much as a clumsy fellow at his elbow. Some men earn not more than 20s. a week, while more skilled comrades will pocket 40s. a week or more,

working at the same terms on identical work. The average wage is about 30s. a week. Preparing parts of locks is often done by day workers at 6d. per hour plus 20 per cent. The preparation of parts for common locks is done by youths and girls at about 8s. per week of 54 hours.

Safe Makers. Boys usually begin at about 15 or 16 years old, earning about 8s. a week in London or 5s. a week in the provinces, and serve until 21 years old, being put on piecework during the last two years. Nominal hours are 54 per week, but the men seldom work their full hours. All work is paid by piece, and the result is 33s. to 45s. a week with an average of about 36s.

Mathematical and Optical Instrument Makers. It is estimated that not more than 10 per cent. of the workmen in this trade have served a regular apprenticeship to it. Apprentices serve seven years, beginning at 6s. per week, and rising 2s. yearly. Standard wages in the London district are 8½d. per hour, but on piecework—which is rather common—9½d. to 1s. per hour may be made, with even an additional bonus when the work is finished. The hours of labour vary from 48 to 56 per week, according to the different shops. Sometimes ordinary rates are paid for overtime, and sometimes one and a quarter rates.

Jewellers. London is the seat of the better-class jewellery trade and the workmen engaged are largely foreign. Apprenticeship exists but is not general. Departmentalism is seriously affecting the quality of the workmen turned out, and the demand for foreign skilled labour shows no sign of decrease. Apprenticeship, where it prevails, is for seven years. Ordinary work is paid for at the rate of 7d. to 1s. per hour, and 1s. to 1s. 6d. for best work. Workmen who have special skill in modelling and designing may make up to as much as £10 a week. Such men are chiefly Frenchmen. Piecework prevails as well as time-work and its remuneration is slightly higher.

Gold beating is a poorly remunerated and a dying craft. owing to foreign competition. Wages average only 20s. to 30s. per week. There are no youths entering the trade.

Gold and silver wire drawing is done chiefly by women, who earn up to 13s. per week. There has been much short time lately on account of slackness. Girls learn the trade in about a year after having been taken on as message girls.

Watchmakers. The English watch trade has gone and no youths are entering it. Most of the workmen now in it are old men who learned the craft in its flourishing days. Wages are by piecework and 40s. to 60s. is the rule for men of skill, but this is little more than half what was formerly a common remuneration.

Clockmaking. The trade of the clockmaker is not in such parlous state as that of the watchmaker. Boys entering the trade are not now taught it properly, as attention to an automatic machine has taken the place of skilled knowledge of horology. Wages are usually 8d. to 9d. per hour for 54 hours' work, and machine minders may earn more according to the work put out, so that 1s. per hour is not uncommon.

Britannia Metal Workers. Apprenticeship general, and obligatory. Boys usually begin at 14 years, earning 4s. per week, and serve seven years, rising to 10s. per week. During apprenticeship, and when the boy has become to some extent master of his craft, he is paid a percentage of piecework rates in addition to his salary, the percentage varying from 2d. to 6d. in different workshops. Workmen are usually on piecework rates, and earn from 30s. to 40s., according to ability. Day wage employees receive 6d. to 8d. per hour. No extra rate is paid for overtime. The working week is 54 hours. These conditions apply both to the spinning and the making up of articles in Britannia metal.

Ironplate Workers. In the Staffordshire district, which is the centre of this trade, departmentalism is ousting the skilled worker in favour of the die press, and the operator is practically only a superior labourer. Apprenticeship is fast dying, and wages have gone down. The payment of workmen is largely by piece rates, which vary in different towns, and nothing extra is paid for overtime. Attempts are being made to standardise wages for the Midlands, but success is extremely doubtful. Work is for 56 hours per week.

In Scotland, apprenticeship in the sheet-metal working trade lasts six years, and there are no general restrictions regarding the number of apprentices. Wages 5s. per week, rising to from 12s. to 14s. Working hours are 51 per week. Adult wages are 8d. per hour, and overtime is paid at one and a half rates.

In the Glasgow district the rules of the Sheet Iron Workers, Light Platers, and Ship Range Society permit one apprentice to every five journeymen. Sometimes this rate is slightly exceeded. Apprentices serve five years, beginning at about 6s. per week, and rising annually by 2s. per week. They are frequently put on piecework during apprenticeship, and earn far more. Workmen's wages vary in different districts, but the average is probably 9d. per hour. Hours of work are 54 per week, with one and a half rate for overtime and double time for Sunday work.

Tinplate Workers. In the Wolverhampton district, which is the centre of this trade, boys serve a seven years' apprenticeship, from the ages of 14 to 21, beginning at 4s. per week, and receiving annual increases of 1s. per week until they are 17 years old, when they are put on piecework, and earn two-thirds of ordinary workmen's piecework rates. One boy is usually allowed for every five men. Certain branches of the trade, such as the making of cycle gear-cases, motor accessories, and gas-meters, are paid 8½d. per hour for 54 hours a week, with one and a quarter rate for overtime. Other work, including dairy work, making lamps and lanterns, and brass, copper, tin, zinc, and iron hollow-ware, ventilators, and Government

contract work are upon a piece scale, and rates differ very much, but are usually slightly higher than the time wages mentioned, and the working week is only 50 hours.

In the Aberdeen district, where there are a fair number of tinplate workers associated with the canning industry, five years' apprenticeship is enforced. Wages begin at 4s., rising to 9s. or 10s. per week. No standard wage rates for workmen, earnings varying from 20s. to 25s., according to ability. Overtime is paid one and a quarter rates.

Brass and Copper Workers. In the North of England, apprenticeship begins at the age of 14, or, if the lad has attended a technical school, at 16, and terminates at 21 years of age. A 14 years' old apprenticeship begins at 4s. and rises to from 16s. to 16s. A 16 years' old apprenticeship begins at 4s., but in three months rises to the scale of an ordinary apprentice of the same age. Brass moulders receive 40s. per week of 53 hours, brass finishers receive 36s. Overtime from 5 p.m. to 7 p.m. is paid at one and a quarter rate, and after 7 p.m. one and a half rate. Lads receive 26s. per week on completion of apprenticeship, but rise to the recognised standard wage 12 months later.

In London there are no indentured apprentices. Boys enter the shop and are put to the lathe and vice, earning 2s. 3d. per working day of nine hours, rising to 6d. per hour. In piecework shops, "improvers"—*i.e.*, boys who have been a few years at the trade, are paid two-fifths, half, or three-fifths adult rates. Artisans' wages range from 8d. per hour upwards, the greater number receiving 8½d. Overtime is paid at one and a quarter rates for first two hours, one and half rates after, and double rates for all-night work and Sundays. The working week has 54 hours.

In Scotland apprentices in general shops serve seven years, and in engineering and shipbuilding shops six years. Wages begin at 3s. per week, and rise 1s. per week each year. Usual rule is one apprentice to five or six journeymen. Standard minimum wages for workmen are: Moulders and coppersmiths, 7½d. per hour; brass finishers, 7d. per hour. First year journeymen, ½d. per hour below standard minimum. In general shops 51 hours per week, with one and a half rate for overtime; in engineering shops, 54 hours per week, with one and a quarter rate for overtime.

Zinc Workers. Irregular apprenticeship common from 15 or 16 till 21 years old, wages usually beginning about 5s. and advancing according to capacity. Work is done both by time and by piece, shop work usually by the latter and outside work by the former. Common wages in London are 5s. 6d. to 6s. 6d. a day, working out at 36s. to 40s. per week. Provincial rates are about 5s. a week less.

Lead Workers. Makers of lead pipes and sheets, lead shot and capsules have no apprenticeship. Workmen of extra skill may earn as much as 35s. a week; but the average rate is 24s. to 28s., although some make not more than 20s. Girls are employed in making and decorating lead bottle capsules, earning 7s. to 12s. a week, or, if forewomen, 16s.

HIDE AND LEATHER TRADES

Skinners. The conditions generally are much as in London, where apprentices must serve five to seven years or be the eldest son of a workman. Usual duration is now five years. Apprentices are on piecework at same rates as the men less 10 per cent., which the employer retains. In all the departments—fleshing, splitting, and puring—piecework is in force, and the wages earned are from 25s. to 45s., from 30s. to 50s., and from 40s. to 70s. respectively.

Fur Skin Dressers and Dyers. Formerly an apprenticeship of five years was common, and lads were taught all the departments of unhairing, shaving, fleshing, etc. Now, for unhairing, lads are usually taken on at the age of 18 and upwards, and learn the trade as best they can in from three to six months, beginning at 20s., rising soon to 25s., and finally 30s. per week. No apprentices have been taken on for the last 10 or 12 years on account of the dearth of skins, which has caused the industry to decline. For entering as shavers and fleshers the conditions are similar, except that the apprenticeship is longer. Work is by piece in all departments, and an expert man may earn twice as much as his less skilled fellow. Dayworkers are employed in the dressing and dyeing departments, and earn from 20s. to 30s. per week. Foremen of the various branches average about 10s. a week more. Hours are 10 per day, except Saturdays, when six hours are worked. Overtime is paid for at 6d. per hour.

Women are employed to do light work and sewing, and earn from 10s. to 16s. per week, working nine hours per day.

Leather Shavers. Apprenticeship uncommon, but five years is the usual time where it prevails. Nearly all work is piecework, and workmen earn from 28s. to 40s. a week according to ability.

Leather Tanners. The trade is very much divided up, nearly each process being one which requires skilled labour, and therefore apprenticeship is pretty general. There are many divisions, and the three largest are the "tanners" or "fleshers," "curriers," and "finishers." All these are paid by the "piece," and earnings depend on the skill and capability of the man. Apprentices are usually bound at 14 or 15 years old, and serve till 21. In some cases they are bound to work on timework for so much per hour, a small rate at first, increasing as the boy grows older and more skilful. In other cases the apprentice is bound to a journeyman to teach him the trade, and is paid by the man a percentage on the work he does. The average working day is nine hours.

A tanner or flesher earns from 30s. to 40s. per week, a currier from 30s. to 50s., and a finisher about the same. There are so many different classes of work that it is extremely difficult to say accurately what is the average earning. We have known finishers to earn up to 80s. per week, but this is exceptional. Apprentices are usually the sons of men employed in the trade, but this is not a condition.

Furriers. Apprenticeship is not very common. Usually a boy of 15 or 16 is taken to learn the trade, and is paid 10s. per week, rising gradually for three or four years. At the end of this time he is considered an improver, and does general work of a not very responsible character. Then he learns nailing and cutting.

A cutter earns from £2 to £3 15s. per week, or even more, and 50 per cent. more for overtime.

The hours are 9 a.m. to 6 p.m. from Christmas to Easter; and from Easter to Christmas, 8.30 a.m. to 7 p.m. Saturdays until 1 or 1.30 p.m. There are chances of a smart man becoming a sorter and buyer of goods and blossoming into a fur merchant.

Saddlery and Harness Makers. There are very few apprentices in London, although premium apprenticeship is not unknown. The rule is five or six years, beginning sometimes as low as 3s. a week and sometimes as high as 8s., and in second and subsequent years the wages are 10s., 12s., 15s., 18s., and 21s. Workmen earn a minimum day wage of 33s. per week, but the best work is paid for by piece calculated to give 10d. per hour. Hours are 52½ per week, and there is practically no overtime. In the provinces the conditions are similar, but the wages are usually less.

Portmanteau Makers. In good shops portmanteau makers are bonus apprentices from 14 to 21 years of age, receiving 5s. a week during the first year and an annual increase of 1s. per week for six years. During the last year the apprentice is put on piecework and paid at half the rates of workmen. All work is by piece, therefore there is no uniformity in earnings, but the average for a good man is 38s. per week of 52 hours. For overtime the workman is paid 2d. per hour in addition to ordinary piecework rates. Good men are always in demand, and need not fear being out of employment, hence the trade is one of the most attractive from the labour point of view.

Boot and Shoe Operatives. Apprentices unusual; sometimes for two, three, or four years. The minimum weekly wage for workmen over 20 years of age is regulated by each centre of the trade for its own district. The rates at present in force in the Leicester district are as follows: Minimum wage for clickers, lasters, and finishers, 29s. per week, and for pressmen who are rough-stuff cutters, 26s. per week. Probably about 25 per cent. of the operatives are on the minimum wage, the remainder earning considerably more, up to 50s. or over per week. Many men are engaged upon piecework payment, rates for which are fixed by the Board of Conciliation and Arbitration. Overtime is paid for at the rate of time and quarter for day workers, and at a 25 per cent. increase for piece-workers. In some other districts there is no recognised higher overtime wage rate. Overtime is not common, however, except for a few weeks before and after stated holidays.

In Scotland, apprenticeship is not now general except in the clicking department, where the lads serve five years, beginning at 5s. or 6s. a week and rising to from 18s. to 21s. per week. Adult operators have a minimum wage of 29s. per week of 54 hours, with time and quarter for overtime.

In Ireland apprenticeship is practically extinct. A steady workman can make 35s. a week without much difficulty; but few of them do so, the majority contenting themselves with the 25s. or 26s. a week which loose attention to the regulation hours of work enables them to earn.

Clog Makers. The apprenticeship system is general; one apprentice to three workmen. Lads serve seven years, or until 21 years of age. Their wages are low during the whole term—starting with about 5s. per week, and finishing with about 13s. per week.

Adult operatives work about 58 or 60 hours per week, starting work at 8.30 or 9 a.m., but there is no rule regulating the hours. They come and go as they please, and as all work is paid for by the piece, there is no extra overtime payment.

Sole makers can earn over 40s. per week, and seatsmen from 27s. to 32s. per week. Wages are always tending upwards, and there has not been one instance of reduction in the last 69 years.

TEXTILE OPERATIVES

Cotton Spinners and Weavers. There is no system of apprenticeship in the cotton trade. For most departments, the operatives need training from early youth as the necessary deftness of the fingers and delicacy of touch can be acquired only during that period. As a rule, they are taken straight from school and employed as "learners." This period lasts only a few weeks, and at present is very short indeed, owing to the scarcity of labour, due to the abnormal increase in the number of mills and weaving sheds. As a rule, no wage is paid during the period of "learning," but inducements are at present offered in the shape of pocket-money.

After say, four, or at most six weeks, the "learner" is put on the duties performed by children or young persons. In spinning mills, these duties are, for girls, back tenting, the average wage for which is about 10s. per week; for boys, little piecing, or "scavenging," as it is called in the Bolton district, the wages for which average about 12s. 6d. The back tenters develop into tenters as soon as they show themselves capable, and there are vacancies. The wages average about 20s.

The little piecers, or scavengers, develop into "big piecers" (sometimes called side piecers), say at 16 or 17 years of age, with wages from 16s. to 22s. per week, and thence into full-fledged minders or spinners, with wages varying from 30s. to 60s. per week. The average spinner's wage is about 40s. per week.

Hours of work are 55½ per week—*viz.*, 6 a.m. to 5.30 p.m., less 1½ hours for meals, and 6 a.m. to 12 noon on Saturdays, less ½ hour for meals. There is no recognised overtime worked in the cotton trade, the chief reason being that child

labour is so necessary to nearly all departments, and the hours of labour for such are fixed by the Factory Acts.

The cotton trade is divided into two main branches—"spinning" and "weaving."

Wages in the great weaving centres differ, of course, from those in the spinning centres, one principal feature being that male and female adult labour at weaving is paid exactly alike. All weavers, whether men or women, are paid the same piecework rates, which are contained in a list which applies to all Lancashire.

Each weaver attends to as many looms as his or her efficiency warrants. It varies from two to six looms, and the earnings range about 6s. 6d. or 7s. per loom. In the case of a weaver minding six looms, a helper is needed, who is paid out of the weaver's earnings.

There are, of course, several processes subsidiary to the main branches of spinning and weaving, which are well defined, and for which special training is needed.

Flax Spinning and Weaving. Flax spinners usually begin as half-timers and fetch and carry to the machines until they are big enough to attend to preparing machines or spinning frames. Half-timers earn from 10d. to 1s. per day, and full timers from 6s. 6d. to 10s. per week. Machine boys earn from 7s. to 8s. 6d. per week, and hecklers (men) from 25s. to 26s. 6d. per week.

Chiefly women are employed in linen weaving, and there is no apprenticeship, the machinery employed being automatic and requiring little learning. Winders—who are women—earn from 12s. 6d. to 15s. per week, and weavers, also women, receive from 9s. to 16s. per week, according to capacity and output. Dressers and tenters, who are men, are paid 28s. per week. Dressers' apprentices serve three years, beginning at 10s. a week and rising to 14s. An apprentice tenter serves four years, beginning at 8s. and rising to 14s. The hours are usually 55½ per week.

Wool Workers. But in the woollen trade itself there is a clear division into two sections—*viz.*, woollen and worsted. The difference, technically, is in the manipulation of the yarn. First as to the worsted trade, which has its centre in and round about Bradford. The hours worked are 55½ per week, and there is now no system of apprenticeship in either spinning or weaving. Children go to the mills as soon as they leave school—the half-timer is a declining quantity—and commence as doffers—that is, removing the bobbins from the frames, and usually graduate into spinners. As doffers they get 7s. 6d. to 9s. 6d. per week, while as spinners, minding two or three frames, they earn from 10s. to 11s. 6d. per week. Before the spinner, however, comes the rover and drawer, the pay of the former being about 10s. per week, and the latter about 11s. Then there is the business of making warps, work for young women who earn from 12s. to 14s. a week, and some on piece work even more. Weaving, of course, comes after these processes, and here the wages vary considerably according to the branch in which the young women and young men and elder persons are engaged. The highest wages are earned in the Huddersfield fancy coating trade, where as much as 25s. can be earned at piece rates, but generally the wages may be taken to run from 14s. to 20s. per week.

In the woollen industry the preliminary processes are not exactly the same, nor are the conditions of employment identical. In a woollen spinning mill a man will take from the master so many mules and engage his own "piecers," or young persons, whose wages run from 10s. per week upward. The wages of weavers run from 13s. upwards, but here, owing to the heavy description of the work, weavers are engaged mostly on one loom, whereas in the worsted trade a weaver will mind two looms pretty generally in the Bradford dress trade, though on high-class work in the Huddersfield coating trade one loom is more nearly the rule. There is no apprenticeship in the Yorkshire woollen industry, and the hours of labour are the same as in the worsted trade.

In the Welsh woollen trade young men are apprenticed as spinners and weavers for three years, and during apprenticeship earn about one-third the full wage of operatives. The wages of spinners are 21s. per week, and weavers are paid by the yard of output. The workmen's union does not permit women to work at spinning or weaving. The latter prepare the yarn for the looms, and earn about 10s. a week. Men receive no extra remuneration for overtime and women do not work overtime.

Woolstaplers. Apprenticeship still in vogue, but becoming less common. It is usually seven years. Apprentices to a woolstapler begin at 2s. 6d. to 4s., and rise to 10s. or 12s. If apprenticed to a manufacturer, 4s. is paid on entering, and the wages rise to 20s. during the last year. Apprentices to a piecework firm are paid a similar remuneration for four years, and during their remaining three years are paid as men, but have to refund the wages paid during the four years. Day-work wages for men are 32s. per week for a nine hours' day, and piecework woolstaplers earn 40s. per week in a 10 hours' day. Little overtime is worked, as daylight is necessary, but short time is frequent during the summer months.

Silk Workers. Apprenticeship prevails to a fair extent in the different departments and its conditions are as follow:

WEAVERS. Apprenticed for about five years until 21. Wages, three-fourths of the rates paid to adults.

PICKERS. Apprenticed for about five years. Wages begin at 9s., advancing 1s. every six months until they reach 20s.

TWISTERS. Apprenticed for two years. Wage about 16 per cent. less than the rate for adults.

MECHANICS. About five years, until 21 years. Wages, 5s., 6s., 7s. 6d., 9s., and 11s. 6d. per week. during the respective years.

The wages of men workers are as follows:

Weavers, from about 24s. to about 40s.; pickers, from about 20s.; twisters, from about 25s. to about 28s.; braid makers, from about

20s. to about 28s.; mechanics, from about 20s. to about 35s. Overtime is paid at the same rates as ordinary time.

The wages of women workers are about as follows:

Hard silk workers, adults, 8s. to 10s.; soft silk workers, adults, 9s. 6d. to 16s.; cotton winders, 9s. 6d. to 16s.; spoolers, 11s. 6d. to 20s.; hand loom weavers, 8s. to 14s.; embroiderers, 12s. to 14s.; lace taggers, 10s. to 15s.; braid workers, 10s. to 15s.; cotton polishers, learners, 8s., advancing to 12s. 6d.

Some manufacturers pay by piecework, as far as practicable, and frequently the cotton workers get more than the wages named above. There is no overtime for women. All workers have 53 hours per week.

Lace Curtain Weavers. In Scotland, the seats of the lace curtain trade are Darvel, Newmilns, Galston, Kilmarnock, Stewarton, and Glasgow. Each of these places has its own rules as to hours of work and wages, but nowhere does apprenticeship prevail. At the same time, the weavers go through a course of learning, starting as shuttlers, thereafter being brass bobbin winders, and assisting for some time at a lace machine before being employed as a lace weaver. There is no special duration of learning, the whole depending on the capability and age of the learner. The hours of the learners depend upon their ages. Up to the age of 16, they can be employed only to 6 p.m.; up to 18, to 10 p.m.; and after that they are engaged as night-time shuttlers until they start assisting at lace machines. In Newmilns, the work is carried on in three shifts of eight hours each, and the wages for the lace weavers range from 25s. to 28s. per week. In Darvel, weavers only work two shifts of ten hours each, the mills being closed during a part of the night, and their wages are paid by results; but the average wage of a good weaver is about 27s. or 28s.

Trimmings Weavers. Apprenticeship limited, as few boys enter the trade. Usual time is six years, beginning at 8s. and rising to 15s. per week. Workmen earn 15s. to 25s. a week. Hours are 54 per week with no overtime.

Tailors. Apprenticeship non-existent in England but usual in Scotland, Ireland, and Wales. In Ireland the trade suffers through excess of apprentices. Apprentices serve five years beginning at 2s. 6d. a week and rising by annual 1s. per week increases. Average wage of workmen 35s. per week of 54 to 60 hours. Overtime not generally recognised, but where it exists rule is payment at one and a quarter ordinary rates.

Tailors' Cutters. Apprenticeship is usual and there is no restriction as to number. Wages vary considerably, average being probably 5s. per week to begin. Apprenticeship usually lasts three years. Wages to competent workmen in London are 40s. per week of 50 hours, with 10d. per hour for overtime.

Felt Hatters. Apprentices usually serve five years. Apprentices' wages vary, but are often on the piece scale, less 20 to 33⅓ per cent. Workmen are paid by the piece, earning from 32s. to 40s. per week, with no extra remuneration for overtime. The standard minimum wages are: Pressers and machine curlers, 32s.; settlers, 33s.; formers, hardeners, machine parers or setters, 35s. Finishing and shaping is done by piecework, with a minimum rate of 35s. One apprentice is allowed for every five journeymen employed. The hours of work are 56 per week. Felt hat trimming is done by women. No apprentices. A girl learner pays 10s. to 20s. to a tutor, and works for her for one month without wages, after which she becomes an ordinary worker and is paid piece rates. Workers earn 15s to 25s. per week of 56 hours.

Silk Hatters. A seven years' indentured apprenticeship compulsory. Workmen are paid by a complicated piecework scale, and earn 40s. to 60s. a week. From January to June hours are 11 per day and from July to December 9 per day. Saturday work ceases at 1 p.m. No overtime allowed, and breakers of this rule are fined 6d. for every five minutes by the workmen's union.

Hosiery Weavers. There is no apprenticeship, the machinery employed being automatic and necessitating little to learn. Standard wages are gauged by a mutually arranged price list. Men earn from 25s. to 45s. per week, women from 16s. to 24s. The hours of work are 55½ per week.

Umbrella Makers. No indentured apprenticeship, but competence is considered to be attained only after eight or nine years' experience. Standard wages for frame makers are 30s. per week, for cutters 33s., and for finishers 30s. per week. The hours are 55 per week and overtime is paid at one and a quarter rates.

Bleachers. No branch of this industry would lend itself to apprenticeship. The various processes are in themselves of a simple character and readily acquired. The custom of the trade is that young persons enter the works and gradually pass upwards from one department to another as they grow older. Bleaching starts in what is called the crofthouse, where the grey cloth undergoes a drastic process of washing and bleaching. The cloth proceeds from the croft to various departments to be filled, calendered, beetled, made up, and packed.

Hours and wages in the bleaching trade vary very much. In some districts the bleachers work upon a piecework basis, and the hours worked per week usually are 55½ to 56½. In other districts it is customary to pay on a time basis at so much per hour, and a working week usually consists of 59 to 60 hours. Wages are much the same as those of dyers, given below.

Dyers. Apprenticeship does not prevail. Boys start at 14 or 15 years of age and receive from 7s. to 10s. per week, rising, usually by increments of 1s. per annum, to 18s. per week, which seems to be the wage among the Staffordshire silk and cotton dyers. Attempts are being made to elevate the status of the

workers. The Yorkshire dyers are better paid, and their standard wage list is as follows:

Department	Bradford	Leeds and Halifax	Country Districts
Crabbing (first man)	26s.	25s.	24s.
,, (second man	24s.	23s.	22s.
Singeing (first man)	26s.	25s.	24s.
,, (second man)	24s.	23s.	22s.
Black Dyehouse Machines (first man)	24s.	23s.	22s.
Jiggers (first man)	24s.	23s.	22s
Colour Dyehouse Machines (first man)	24s.	23s.	22s.
Padding (first man)	24s.	23s.	22s.
Jiggers (first man)	24s.	23s.	22s.
Drying machine (first man)	26s.	25s.	24s.
Washing-off Machines (first man)	24s.	23s.	22s.
Black Rolling Department (first man)	24s.	23s.	22s.
Firers	24s.	24s.	24s.
Tub Skeiners	24s.	—	—

Usual day's work is 6 a.m. to 6 p.m. Overtime after 7 p.m. is paid time and half, but night-shift men receive only 6d. extra per night. The workmen's unions control the taking on of new men.

Carpet Weavers. In England the taking of apprentices depends upon the vacancies that may occur. Apprentices begin between the ages of 13 and 15, and are generally 20 before being entrusted with a loom. If specially capable a youth may receive a loom at 18, but has 1s. 8d. per £ deducted from his earnings until he is 21 years old. In the Leeds district, 3d. per shilling is deducted from the earnings of apprentices up to 18 years of age, and 2d. up to 21 years of age. One penny per shilling on all fabrics for winding is deducted before the apprentice's fee is taken off. The foregoing principles apply to Venetians and Dutch. The charge for learning is paid by the employers. The duty of the usual apprentice is to attend to the requirements of two weavers, and he receives as salary 3s. 9d. in the £ of their joint earnings, which sum is paid by the firm. The apprentice usually earns anything from 8s. to 15s. per week. Weavers' wages are regulated by the "Kidderminster Price List," but under ordinary circumstances the weaver receives 30s. to 45s. for 55½ hours' work. No extra rate is paid for overtime. In the Scottish carpet trade apprentices are accepted only after having been four years at the looms. First year 12s. to 14s. a week is paid. During the second year they are paid 75 per cent. of the piecework wages paid to men. Sometimes during the third year this deduction of 25 per cent. is placed in the bank by the employer and handed to the worker in a lump sum upon the completion of his apprenticeship. Carpet weavers are paid by the piece, and rank high among textile operatives.

Floor-cloth and Linoleum Printers. Apprentices begin at 10s. per week and rise by 1s. a year during five years. Standard time wages in Scotland are 25s. per week. Overtime is paid time and a quarter. Most of the hand printing is now done under piecework prices, and the workers earn more under this system.

Rope and Twine Operatives. Apprenticeship fairly general and lasts seven years, beginning at 6s. and rising to 14s. per week. The standard wages of journeymen are 28s. per week for a 10½ hours' day. Overtime during first two hours paid at time and a quarter rates, second two hours time and a half rates, and any longer time or holiday work paid double.

Mat Makers. There is no apprenticeship in mat making proper, but apprentices serve for three years to matting weaving. The wages of workmen vary in different parts of the country. In London the average is about 30s. per week, and in the country from 20s. to 25s. Nearly all the work is paid at piece rates, and there is practically no overtime.

WOODWORKING

Sawmill Operatives. Nearly all sawyers and machine men serve four years' apprenticeship, and saw doctors six to seven years. Apprenticeship wages, 12s. to 20s. per week, and occasionally more. Sawyers' wages range from 7d. to 9d. per hour, and machine men from 7½d. to 10½d. per hour, depending somewhat upon the nature of the machine worked, and upon the skill of the operator. Hours vary from 51 to 54 per week, and overtime wages from one and a quarter to one and a half rates.

Saw doctors earn from 36s. per week, and the average is about 40s. Those in sawmills and shipyards have a 54-hour week, and those employed by joiners, builders, and cabinet-makers work 51 hours per week.

Carpenters. See under Building Trades.

Cabinetmakers. Influences which have modified the conditions of carpenters and joiners have brought similar but more accentuated results to the cabinet-making trades in England. The conditions of apprenticeship in the latter approximate to those given under Carpenters. The wages and working hours of cabinetmakers vary widely. The following show the conditions in several representative towns:

District.	Rate of Wages per hour or per Week.	Hours of Labour per Week.
Aberdeen	7d. to 8½d. per hour	51
Barrow-in-Furness	36s. to 38s.	54
Belfast	36s. in Town	52½
	38s. 3d. in	54
Birmingham	38s. 3d. to 42s. 9d.	54
Bradford	8½d. per hour	54
Bristol	28s. to 35s.	56
Carlisle	7½d. to 8d. per hour	50
Dublin	35s.	54
Edinburgh	8½d. per hour	51
Glasgow	7d. to 10d. per hour	51
Hull	7½d. per hour	55½
Isle of Man (Douglas)	28s. to 30s.	54
Leeds	9d. per hour	49½
Liverpool	9½d. per hour	49½
London	9½d. to 10½d. per hour	50
Londonderry	28s. to 30s.	54
Manchester	9½d. hour; carvers 10d.	48
Middlesbrough	8½d. to 9d. per hour	53
Newcastle-on-Tyne	9½d. per hour	50
	37s. in shipyards	54
Nottingham	8½d. to 9d. per hour	54
Preston	8d. to 8½d. per hour	49½ to 54
Sheffield	8½d. per hour	52½
Wolverhampton	7½d. to 8d. per hour	54
York	30s. to 32s.	

Overtime usually one and a quarter ordinary rate, but sometimes one and a half rate, and even double rate for special work and for certain days. Piecework is becoming more common, and under its conditions wages are higher and the work harder. Departmentalism is influencing the general efficiency of the workmen, who are becoming specialists in their departments, thereby lessening their chances of securing occupation if necessity requires a change of employer.

In Scotland apprenticeship prevails in all the different branches of the trade. Apprentice cabinetmakers, chairmakers, and polishers usually serve one year's probation at 4s. a week, and then a proper five years' apprenticeship, earning 5s. 6d., 7s., 9s., 11s., and 15s. during the respective years. Upholsterers and carvers serve six years and earn similar wages. The minimum wages for cabinetmakers, chairmakers, and French polishers are 7½d. per hour, and of carvers and upholsterers 8½d. per hour. The minimum rates for machine men are as follow:

Boring and morticing machines	6½d. per hour.
Tenoning machines	7d. ,,
Band, fret, german, and circular saws	7½d. ,,
Planing, dovetailing, yankee, and straight moulding machines	7½d. ,,
Spindle machine	8d. ,,
General hand	8d. ,,
Hand turner	7d. ,,

Men may earn much more on piecework. Time workers have one and a quarter rate for first five hours overtime, and one and a half rate afterwards.

In Dublin there is a revulsion from the former looseness of the apprenticeship system. A few years ago the employers found that so-called apprentices finished their time without a proper knowledge of their trade, and they now bind apprentices for seven years, the wages beginning at 2s. 6d. a week, and rising to 20s. during the last year. This practice is making for good quality in Dublin-made furniture. The standard wages for men are 35s. per week of 54 hours, with one and a quarter rate for overtime beyond two hours.

Carriage Builders. In England, apprenticeship lasts for seven years, usually beginning at 3s. per week and advancing by 1s. to 2s. increments each year.

The wages of adult operatives are from 34s. to 40s. per week of 53 hours, and the remuneration for overtime is time and a quarter. Many employers give their apprentices double time for overtime. The wages of the adult operatives vary somewhat, as, although a smith gets, say, 38s. there are many other workmen who may get 40s. and 42s. per week. In fact, a man is practically worth what he makes himself worth, as machinery is not used to any great extent. Smiths, vicemen, bodymakers, painters and trimmers are in practically constant employment.

In Wales apprenticeship is common, especially in the wheelwright and wood trade, but not so common in the smiths and painting departments. Many boys enter the trade after being strikers for a smith or handy lad in the paint shop. Apprenticeship, where it prevails, ranges from three to five years; sometimes a premium of £5 to £10 is demanded. Wages are 2s. 6d. for first year, rising by 2s. 6d. annual increases. After apprenticeship, a youth usually serves two years as improver at 18s. to 20s. per week. Average wage for workmen is 32s. per week of 54 hours. Overtime varies from ordinary rate to one and a quarter time.

In the Scottish van and lorry trade apprenticeship is for five years, with 5s. a week, rising by 1s. per week every six months. Wages of first-class men average 34s. per week of 54 hours with one and a quarter rate for overtime.

Railway Waggon and Carriage Makers. Apprenticeship is fairly general, and lasts four or five years, beginning at 1s. per day and rising to 2s. during last year. Apprentices in piecework shops are often paid more, sometimes half as much again. Contract shops work nine hours per day on piecework. In the colliery districts, 9½ hours per day on day wages is the rule. In contract shops, 32s. per week is the usual workmen's wage, and overtime is paid at one and a quarter rates. In colliery districts, general wages are 30s. per week, with no extra for overtime. In these districts, workmen complain that during the summer time they are often required to work for six hours, up to 12.30 p.m., and receive only half a day's pay; also, that they are often required not to work on Saturdays, thereby forfeiting a whole day's pay. The employers in this department are few, and the men, therefore, unable to enforce better conditions of labour.

Coopers. Apprenticeship general and usually imperative. Time served, seven years, beginning at 4s. per week, and rising annually 1s. or sometimes 2s. per week. After third or fourth year, however, apprentices are frequently put on piece rates, receiving half, and during the last year of apprenticeship two-thirds of the journeyman's standard wage. Standard wages in the Midlands for *wet coopers* are 6s. 6d. per day, or 36s. 6d. per week of 54 hours, with 10d. per hour for overtime. London wages are 7s. 6d. to 8s. 6d. per nine hours' day.

GLASS AND EARTHENWARE TRADES

Bottle Makers. Apprentices serve five or six years, beginning at 15s. and rising to 30s. a week. There is usually about one apprentice to every six workmen. In the Glasgow district, which may be taken as typical, the weekly wages are as follow: Finishers, 33s. 6d. and 1s. 6d. per gross for overwork; blowers, 30s. 6d. and 1s. 2d. per gross for overwork; gatherers, 24s. 6d. and 10d. per gross for overwork. Work is for 50 and 51 hours per week. In the North of England conditions are somewhat similar. Lads begin apprenticeship at from 14 to 16 years of age and finish at 21. Average wages are: finishers, 55s.; blowers, 47s. 6d., and gatherers, 40s. Apprentices during their last stages earn 21s. per week. The week's work consists of five or six 10-hour shifts.

Flint-glass Makers. A boy begins in the glass works at the age of 14, and works about two years before becoming a properly recognised apprentice. He usually serves until 21 years old in most parts of England, but in some departments of the trade must serve seven years after beginning apprenticeship. In London, the lad is not apprenticed at all, but works as a boy assistant, until skill and a vacancy gives him the opportunity of taking position as a workman. In the provinces he begins at the standard wage of 5s. or 6s. a week, rising 1s. per week annually for 33 hours' work or 11 "moves," as they are called. Overtime is paid pro rata. The usual practice is to work 13 or 14 moves per week, which gives a wage of 8s. for 14 moves, on a basis of 6s. standard. One apprentice is usually allowed for every two "chairs." A chair usually consists of three men and a boy or boys, the apprentice taking the place of one of the men. Each chair is made up of three distinct workmen—a *workman*, a *servitor*, and a *footmaker*. All are skilled workmen, except when an apprentice takes the place of one of the workmen. The earnings of the three classes vary according to the class of work to which they are accustomed. The chairs are divided into first, second, and third class. For instance, a chair making best light wine-glasses, commonly known as "straw stems," receives a better standard wage than a chair making ordinary wines and goblets; and one making all kinds of cutting work earns more than another making small electric shades and chimneys. The standard provincial wages for a week of 11 moves for the various classes are as follow: Workmen, 30s. to 40s.; servitors, 24s. to 28s. 6d.; footmakers, 19s. to 21s. In London, wages are considerably higher, piecework being general. All work except new patterns and matchings is piecework, and work declared unfit after making causes the whole chair to suffer in wages. If the articles are cracked or melted in the bar while being annealed, the usual custom is to pay half rates.

Work is continuous, and is carried on by six-hour shifts, each man usually working six, seven, or eight shifts per week, as the nature of the work and the condition of trade permit. Overtime is paid pro rata, upon the standard basis for 11 moves per week.

Glass Bevellers and Silverers. Apprenticeship usual in the several branches. *Shape workers*—bevellers who follow curves and fancy patterns—receive 10d. to 1s. or even more per hour, and average 42s. to 45s. per week throughout the year. *Straight workers*, whose work lies only in straight lines, are paid by piece and average about 36s. per week. *Cutters* earn about 40s. or 42s. per week, and *siders* who clean mirror plates in preparation for silvering receive about 30s. *Silverers* make 30s. to 40s. a week, according to skill. Usual hours of working for all classes are 54 per week.

Pottery Workers. In a pottery there are several different kinds of workpeople. The thrower—that is, the man who moulds the dish with his hands as it revolves on the potter's wheel—is the most important man, and may be termed the "potter." The others are the men who prepare the clay, those who make dishes into moulds, and those who fire them in the kilns. The throwers alone have apprentices, who serve usually for seven, but sometimes for five years, and the common hours are from 6 a.m. to 6 p.m. Wages begin about 4s. per week, but the lad soon gets piecework, for which he is usually paid half a journeyman's wage. For the last three years he gets two-thirds. The apprentices are frequently limited to one for every five journeymen. A journeyman may earn from 40s. to 50s. per week on full time, but the average is about 30s. For high-class work, much more money may be made and many operatives earn double the amount stated. Sixty hours per week is the time, but pieceworkers are not tied down to these hours. Overtime is usually at the same rate as ordinary time.

There are a large number of women workers in potteries, mostly helpers, who finish the work of the men. Such women are paid 12s. to 15s. per week. Some women work light machines and earn from 20s. to 25s. per week.

Earthenware Decorators. In Staffordshire a seven years' apprenticeship is essential. Wages are 2s. and 4s. respectively during first and second years. During third and fourth years pay is half ordinary piecework rates; in fifth and sixth years, two-thirds, and in seventh year five-sixths of piecework rates. Thus, the apprentice usually receives about 7s. 6d. a week during third year, and rises to 25s. a week in seventh year. The whole of the trade is practically on piecework, and for common commercial goods the workman earns between 25s. and 36s. a week. Specialists who by ability and application rise to the dignity of artists in their craft earn £2 to £6 a week. About 10 per cent. of the workmen are specialists earning these special prices. Overlookers are paid about 40s. a week. The hours are from 45 to 50 per week, and overtime is remunerated at the same rate as ordinary time.

PAPER AND PRINTING TRADES

Paper Makers. No apprenticeship general, except in the manufacture of handmade paper. In the Lancashire paper mills the following are recognised as the average wages of workmen who work 60 hours a week: Machinemen, £2 5s.; assistant machinemen, £1 1s.; beatermen, £2 4s.; picker boys, 12s. 6d.; potchermen, £1 4s.; fillers-in, or beaters, £1; pressplatemen, £1; boilerhousemen, £1 2s.; roastermen, £1 3s.; firemen, £1 7s. 6d.; steam enginemen, £1 8s.; cullendermen, £1 2s.; cuttermen, £1 5s.; cutter boys, 10s.; reelermen, £1 5s.; rag sorters, 13s.; overhaulers, 17s. 6d.; finishers, £1 8s.; general labourers, 19s. 6d.; bleach-housemen, 21s. In other districts, wages are from 2s. 6d. to 15s. per week less. In some mills work is divided between two twelve-hour shifts, but in Sheffield three eight-hour shifts are the rule. Overtime sometimes paid on the regular rates and sometimes up to 50 per cent. extra.

Paper-stainers. Apprenticeship, formerly common, is now infrequent. Boys help the workmen and receive 5s. to 7s. a week. If they show aptitude they may be taken on as workmen after the age of 16. Payment of the workman is by piece and amounts to 40s. to 48s. a week, from which the pay of the boy helper has to be deducted. Machine workers are paid by time, earning 30s. to 40s. a week and occasionally more. Labourers are paid about 25s. a week.

Engravers and Process Workers. Apprentices serve five to seven years, beginning at 14 years of age upwards. Time spent in technical schools reckoned as apprenticeship. Occasionally premiums are required, but usually apprentices begin at 4s. per week and rise to 12s. Litho artists in London receive about 50s. per week, and in the provinces about 45s. Many competent chromo artists are paid £3, £4, and even £5 per week. Competent etchers receive 50s. in the provinces and 60s. in London. Hours of work for all classes usually 46½ per week. Overtime up to 9 p.m. on ordinary days and 4 p.m. on Saturdays is paid at time and a quarter rates, and at double time after these hours and on holidays.

Electrotypers and Stereotypers. In London and other large centres the usual apprenticeship is seven years, beginning at 6s. and rising by successive stages of 7s., 8s., 10s., 12s., and 18s. per week to 24s. per week during the last year. The minimum London wage for a skilled workmen is 40s. per week. Evening newspaper work is paid at the rate of 47s. per week, and morning newspaper work 52s. For overtime the first four hours are paid at one and a quarter rates, and afterwards one and a half rate is allowed.

Compositors. Apprenticeship general; length, seven years. Beginning wage varies, usually 4s. to 5s., rising 2s. per week per year. London compositors usually earn 39s. for 52½ hours' work. Overtime paid 3½d. per hour extra for first three hours, 4d. per hour extra for next two hours, and 5d. per hour afterwards.

Printers' readers are usually promoted from the composing-room, and work the same number of hours. Their remuneration is from 42s. per week upwards.

Linotype and monotype machine operators are also taken from the composing-room. The hours are shorter, only 48 per week, and wages begin at 45s. in London. Piecework is the rule on newspaper work. London standard piecework rates are 3d. per 1,000 ens, and 3¼d. per 1,000 ens for type larger than brevier. Newspaper work is more highly remunerated, the rates being 3½d. per 1,000 ens for evening papers, 3¾d. per 1,000 ens for morning papers, and ¼d. per 1,000 ens additional in each case for all types above brevier. Good men can easily earn £3 to £4 per week, and operators of exceptional speed a good deal more.

Machine Printers. The relation of apprentices to journeymen is usually regulated by a sliding scale. In a small shop the proportion may be one to three, but in a large shop where over 30 journeymen are working, one to three is the rule. Apprentices are usually over 20 years of age before they begin, and are generally youths who have helped the printers, doing backtenting work. Apprentices serve seven years, earn 16s. to 20s. per week during the first year, and rise to about 28s. 6d. in the last year. The wage of a journeyman varies according to the machine in his charge. Tenders of 6-colour machines receive 44s. to 45s. per week, of 8-colour machines 46s. to 48s. per week, of 10 and 12-colour machines 50s. per week, and of 16-colour machines 52s. 6d. per week. The week is one of 56 hours' work. Overtime is not allowed beyond one hour per day, and that hour must be paid at time and a half rate.

Plate Printers. Apprenticeship usually lasts seven years, beginning at 6s. a week with a 2s. per week increase each year. Occasionally more is paid, especially when the lad is put on piecework, when he may earn as much as 25s. during the latter part of his apprenticeship; 90 per cent. of the workmen are on piecework, and the average earnings are about 42s. Men of exceptional skill may earn more, say £3 or over. Hours are from 9 a.m. to 7 p.m. No extra remuneration for overtime, but night work is paid 1s. to 2s. 6d. per night above ordinary piecework rates.

Bookbinders' and Machine Rulers. Apprenticeship general, usually by indenture; usual period seven years. Wages begin at 5s. per week, rising to 12s. or sometimes 16s. per week during last year. Unindentured apprentices frequently change employment before time is up, and earn as much as 20s. as improvers. Workmen's union favours indentured apprenticeship. Journeymen's wages are higher in the large centres than they are in smaller towns, and the standard minimum varies from 35s. per week of 48 hours to 30s. per week of 54 hours.

Lithographers. Apprenticeship usual. Duration, six to seven years, beginning at 5s. per week, and rising to 10s. or 15s. Workmen earn 34s. to 50s., hours being 48 to 54 per week.

Bookbinders. Apprenticeship fairly general, especially in the best leather and miscellaneous binderies; duration, seven years. Wages, 5s. per week, rising to 15s. or 20s. In London there is a specific minimum wage rate. Forwarders receive 35s. for 48 hours. Finishers receive the minimum of 36s. for 48 hours. Pieceworkers of average skill make at least 1s. per hour. Overtime, 25 per cent. extra after 52½ hours, or after 10 hours in any one day in all departments. These rules do not apply to vellum binders, who are paid special rates.

MISCELLANEOUS TRADES

Bakers and Confectioners. Wages and conditions vary much in different districts. In large factories in London, adult hands receive 30s. per week, and all time beyond 10 hours in any one day is paid for at 50 per cent. above ordinary rate. London shop hands are divided into four grades, and are paid as follow: Forehands, 36s. per week; Scotch fore or single hands, 33s. per week; second hands, 30s. per

week; all other adult hands, 27s. per week. Young men between 18 and 21 years of age, who are not engaged in moulding and dough making, but are occupied partly in the bakehouse and partly as barrow men receive 22s. per week or more. Jobber forehands receive 6s. 6d. per day for 10 hours' work, and other jobbers 5s. 6d. per day, overtime being paid at time and a half rates, and Sunday labour is paid double. Hours worked are 60 per week. In provincial towns, where the operative bakers are associated, the conditions approximate to those in London, but in smaller towns the position of the workman baker is not so satisfactory.

In Ireland the Bakers Union insists on a five years' apprenticeship, but in some small towns only three or four years are served. In the cities the proportion of apprentices is restricted. In Belfast, for instance, it is one to four men. Usual apprenticeship wages, 5s. to 7s. a week during first year, rising annually 1s. per week. Wages of workmen vary from 22s. a week in a few country districts to 34s. in Belfast, Dublin, and Limerick. Hours average 54 per week, but are 52 in some larger centres. Overtime is discouraged, but is frequently paid 9d. per hour. In Belfast and Dublin night work is common, but elsewhere day work is the rule.

In Scotland the bakers in and around Glasgow are the most highly remunerated, the minimum weekly wage being usually 34s. In Edinburgh it is 28s.; in Aberdeen, 30s.; in Dundee, 31s. In small towns such as Brechin, Forfar, and Inverurie it is only 24s. Hours of working vary from 51 to 57 per week. Apprentices serve five years and must not be less than 16 years old when they begin.

Basket-makers. Apprenticeship is still the rule in the chief centres when the work is done in factories, but many of the chief baskets are made by "sweated industry," when the wages of the workpeople are barely sufficient to sustain existence. Apprentices to basket-making are perhaps usually the sons of basket-makers, and there is nothing approaching uniformity in apprenticeship wages. Work is paid by piece, and the scale is regulated by the trade societies in the large centres. The most skilled workers may make as much as 50s. a week when busy, but the average for good men is between 30s. and 35s., while those on common work earn about 5s. less. Hours are nominally about 56 per week.

Bamboo and cane work is chiefly done by foreigners in London who work hard for very little money, a male adult worker averaging perhaps only from 15s. to 20s. per week of 60 to 70 hours. There are a few places where better conditions prevail, but these are limited and confined to high-class work.

Chemical Trades. In most of the manufacturing chemical trades apprenticeship is unknown. The experts are scientists who are paid in accordance with ability, and are professional men. The workmen are supervised by foremen who receive 40s. to 50s. per week. The workmen are merely labourers divided into chemical labourers and yard labourers. Leading hands in the former class are paid 6d. or 7d. per hour, making 27s. to 32s. per week of 54 hours, and ordinary hands, 20s. to 27s. per week. Yard labourers receive a little less. Overtime is frequent in some works and is remunerated at one and a quarter ordinary rate.

White-lead workers, whose work is unhealthy, usually receive 7s. 6d. per day, but are not allowed to work more than three days in one week. Other men in white-lead works usually earn 19s. to 22s. per week of 56 to 59 hours.

In soap, candle, and glue works payment is sometimes by piece and sometimes by time. Unskilled men earn from 20s. to 25s.; first-class labourers and workers of medium ability up to 40s. a week; and foremen and men of special skill over 40s. Women and boys are also employed, the former earning 9s. to 15s. and the latter from 6s. to 15s.

Piano Makers. The trade is becoming less skilled than formerly on account of the subdivision of labour, and there are no apprentices proper. Boys who wish to learn the trade thoroughly should enter the employment of one of the smaller makers. The average earnings for the different workmen are as follow:

Back makers, by piece, earning 40s. to 45s. in time of pressure, but only 25s. to 30s. in slackness. Bellyers and markers off, 10d. to 11d. per hour. Stringers (usually boys), 6d. per hour. Fitters up, 8d. to 1s. per hour, average about 9d. to 10d. Finishers and regulators, the most skilled of the workmen, 40s. to 60s. per week.

Indiarubber Workers. Apprenticeship not the rule. Youths taken on for two and three years at wages according to age. In English works workmen earn 35s. to 38s. per week for 48 to 56 hours. Sometimes overtime is paid at time and a quarter rates.

Electric cable makers are poorly paid. The work is not skilled, as machinery, largely automatic, is employed extensively. The men earn only from 4½d. to 6d. per hour on day work with the average about 5¼d. In a few processes piecework is practised and the earnings in such a case may rise to 33s. or 34s. per week. The hours worked are usually about 60 per week.

Electrical Workers. There are many classes of workmen in the electrical engineering trades. To lay and repair the service mains there are service layers, bricklayers, and labourers, who earn 8d., 9½d., and 6d. per hour respectively. Wiremen and jointers earn from 7½d. to 9½d. per hour. Apprentices do not learn the trade; labourers or boy helpers develop the ability and become wiremen. In electrical engineering works boys usually serve four to six years, beginning at 5s. per week, and usually rising 2s. annually. Men's wages are from 8½d. to 10d. per hour. Overtime, one and a quarter rates for first two hours, and one and a half rates for longer. Sundays and bank holidays, double rates. Week has 54 working hours.

THE ART OF THE EAST

Chaldea and Assyria: The Dawn of Realism. Persia: Ec'ecticism and Love of Splendour. Phœnicia, Judæa, and the Far East

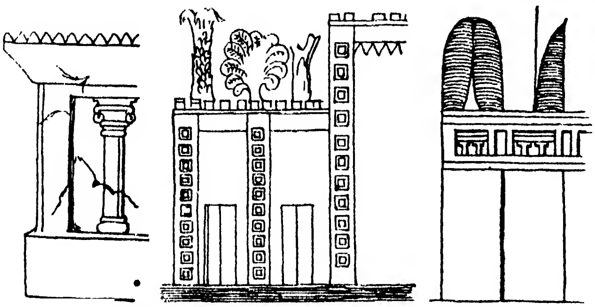
continued from page 2523

By P. G. KONODY

COMPARED with the knowledge we have of the art of the ancient Egyptians, our reconstruction of the art of the early Asiatic Empires, of Babylonia and Assyria, is comparatively fragmentary, based, as it is, mainly on the results of Layard's and Botta's excavations. The monumental works of the peoples settled on the banks of the Euphrates and Tigris were not as durable as those of the Nile valley, owing to the destructibility of the building material, which consisted mainly of sun-dried bricks clad with coloured and glazed tiles and alabaster slabs, decorated with relief carvings on which we have to rely for our knowledge of these civilisations.

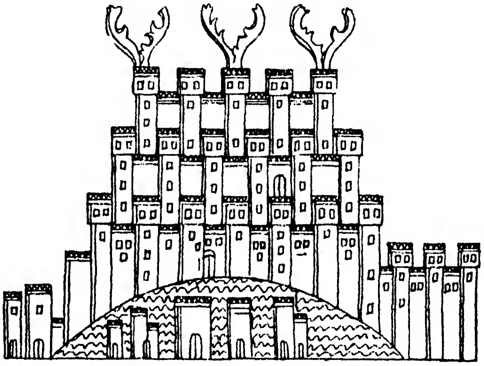
Babylon. A few shapeless sandhills are all that is left of the mighty city of Babylon, but we know from ancient records the colossal extent of the strong walls by which the city was encircled. We know that the pyramidal Temple of Baal was built in eight terraces on a basis of about 800 ft., and that the famous "Hanging Gardens" of Semiramis were laid out in similar fashion on pyramidal terraces [17]. Some Chaldean bas-reliefs and statues of extraordinarily skilled workmanship that were unearthed about thirty years ago by M. de Sarzec at Tello, the site of a Royal palace, date from about 3000–2000 B.C.

The earliest remains of Chaldean art prove conclusively the striking difference between the Chaldean and Egyptian art ideal. In Egypt we have found a striving for monumental repose, and a simplification of form which often resulted in smooth surfaces without even a suggestion of bones and muscles. The turban-covered head of Tello, now in the Louvre, and the diorite statues from the same site, notably the one known as "The Architect of Tello" [19], are marked by that sharp characterisation and pronounced realism which is the most striking feature of all Chaldean and Assyrian plastic art. There is more expression in this head of Tello than in all Egyptian sculpture, and the sturdy, thick-set figure of the architect has the muscles and bones modelled with rare knowledge of anatomy. This so called "Architect of Tello" represents actually Gudea, King or Governor of Shirpurla.



DETAILS OF ASSYRIAN ARCHITECTURE

Assyrian Art. The chief aim of these sculptors was the expression of physical strength and power and muscular exertion. And the later Assyrian reliefs from the palace at Nineveh, of about 800–600 B.C., show the same characteristics, the same cult of strength and keen observation of men and animals in action, the motifs being found in scenes of the chase and of war [21–3]. It was an entirely worldly, realistic art, as op-



18. ASSYRIAN FORTRESS

posed to that of the Egyptians, whose chisels were devoted to the cult of the dead, of the gods, and of the god-like kings. These Assyrian reliefs are far less naïve in the treatment of the human form than those of Egypt, where, it will be remembered, the torso is always shown turned to the spectator, whilst head and feet are in profile. The attitudes are perfectly natural and not forced into a rigid convention.

As regards the representation of animals, the Assyrians reached a perfection of realistic statement that has rarely been equalled, and never surpassed, in the entire history of art. One need only instance the world-famed dying lion at the British Museum [21]. The suggestion of the roundness of form and of muscular development is the more astounding, as the relief is exceedingly shallow and very little raised above the surface of the background, and yet the modelling is suggested with extraordinary subtlety and truth.

Assyrian Sculpture. The sculpture of the Assyrians was almost entirely in the service of their architecture. Only very few free-standing statues have been found on the ancient

sites, but we know that the interiors and part of the exteriors of the temples and palaces were entirely covered with reliefs [24]. The most curious invention of the Assyrian genius was based on an idea similar to that of the Egyptian sphinx, and took the shape of a winged bull with a bearded man's head. Carved in high relief, these figures flanked the entrance-gates of the palaces, and were so disposed that a profile view of the mythic creature was gained from the front of the building, and a full-face view from within the portal. To obtain this end the man-beast was provided with five legs, of which four only could be seen in the profile, and two in the full-face view. To the Assyrian is due the conception of the winged angel, which has been handed down through the ages to play so important a part in Christian art, though the "Kherubim" of that warlike race were grim creatures, bearded, and of a distinctly Semitic type.

Construction of Assyrian Temples. In architecture the Assyrians must be given credit for the invention of the vault and cupola, which were extensively used in the building of their palaces and temples; but the palaces, at least, show neither symmetry nor any proper architectural articulation. On a brick terrace with a stone parapet the rooms and halls were built in a haphazard way around an open court, as though the long, corridor-like apartments had been added one by one, as occasion arose, without any preconceived scheme. The wall decoration consisted partly of alabaster reliefs, partly of glazed and enamelled bricks in brilliant colours. Similarly, the floors were laid out in coloured bricks in purely ornamental designs of great variety and beauty, the motifs being generally suggested by plant forms [20]. There can be little doubt that many of the typical Greek ornamental devices were based on these Eastern prototypes, just as Greek sculpture in its early stages appears to have much in common with Assyrian—certainly more than with Egyptian sculpture.

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19. CAST OF STATUE OF GUDEA (British Museum)

Peculiarity of Assyrian Columns. The buildings rose terrace-like in several storeys, each storey being crowned by a little gallery with short columns, which provided the interior with light and air. Probably light was also allowed to enter through openings in the vaults or cupolas. The walls were divided by pilasters at regular intervals and crowned by a parapet [17 and 18]. The use of columns played a very subordinate part in Assyrian architecture—probably owing to the lack of suitable stone—and pillared halls, such as those of the great Egyptian temples, were probably quite unknown. Where columns occur, they are generally of moderate height and carry a curious form of capital, consisting of two pairs of volutes placed one on the top of the other [17]. Sometimes these short columns rest on the backs of walking lions, a device frequently resorted to at a later period by the Italian sculptors of the thirteenth and fourteenth centuries. See, for example, Niccola Pisano's pulpit in Pisa.

Temple at Khorsabad. Of the enormous extent of some of these palace buildings, the excavations at Khorsabad may give some idea. The brick terrace on which the palace was raised has been calculated to have occupied about 40,000,000 cubic feet. About 210 apartments, many of which were decorated with wall paintings, were arranged around thirty courts. The temple pyramid by the side of the palace had seven steps, four of which—each 20 feet high—are still extant. Each of the seven storeys was resplendent in a different colour, symbolic of one of the seven planets. The porches had round arches built of specially formed, wedge-shaped enamelled bricks.

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20. MARBLE PAVEMENT SLAB SHOWING BABYLONIAN CARPET PATTERN (British Museum

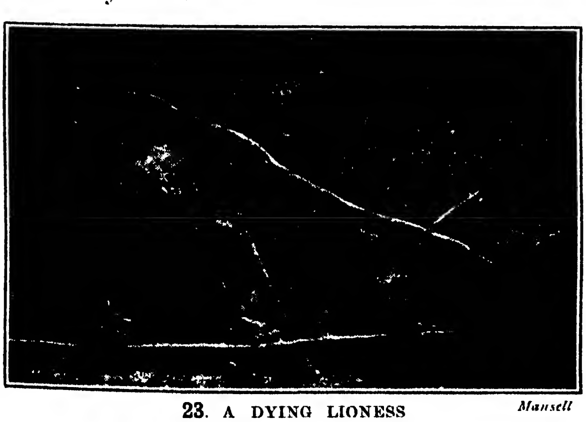
We have no record of the pictorial art of Chaldea and Assyria. All we

know is that bright colour played an important part in their architecture and sculpture, and that even their reliefs show unmistakable traces of having originally been painted. In the use of precious metals and of bronze the Assyrians attained considerable skill, though they did not rival the sumptuous splendour of the Persians under the Achæmenides, who used gold and silver lavishly for architectural purposes.

21. A DYING LION
(Marble Slab from Nineveh at British Museum)

Early Persian Art. The art of ancient Persia was of a distinctly eclectic type, and never reached any degree of independence. The love of splendid, dazzling display of the powerful dynasty that ruled over Persia after the fall of the Assyrian Empire in the middle of the sixth century B.C., was grafted on to the artistic traditions of Assyria, of the Ionian Greeks in Asia Minor, and, to a lesser extent, even of Egypt. Thus the terraced pyramids of the temples, the winged bulls, the treatment of the relief decorations show the Assyrian influence; the slender, grooved columns, the use of marble as building material, the introduction of the triangular pediment as architectural motif, are certainly due to Ionian influence; whilst the cornice above the door of the Royal tombs near Merdascht is distinctly Egyptian in type. The only form developed by the Persians themselves is the thoroughly characteristic and generally rather over - decorated capital, consisting sometimes of a pair of bulls or unicorns back to back; or, again, of two flower cups—one upright, the other and lower one turned downwards — upon which rest some pairs of volutes, rather like those of the Assyrian capitals, but placed upright instead of horizontally. Other columns, again, have the flower-cups, the volutes, and the unicorns, an accumulation of decorative ideas which entirely destroys the proportions of the capital to the column. The interiors were decorated with rich carpets, glazed tiles, and profuse employment of gold and silver. In some apartments the ceilings were, like the roofs, covered with plaques of gold and silver.

22. ATTENDANT AND DOGS *Mansell*
(Marble Slab from Nineveh at British Museum)



23. A DYING LIONESS *Mansell*
(Marble Slab from Nineveh at British Museum)

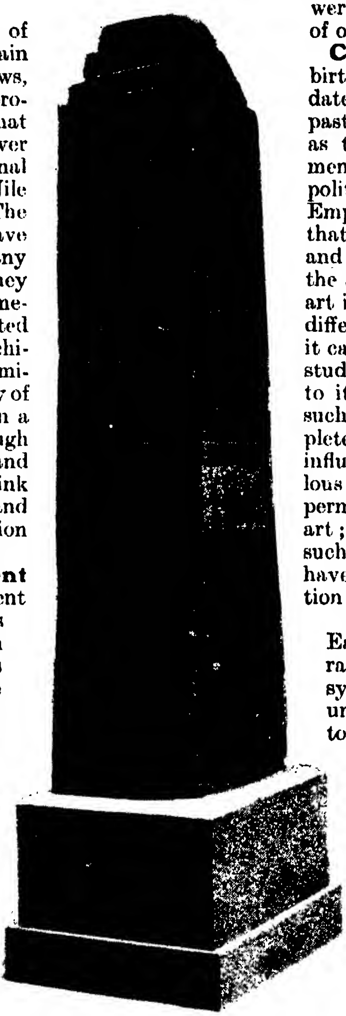
Persian Relief Sculpture. The relief sculpture has something of the hierarchic dignity of Egyptian, and something of the realism of Assyrian art. The subject matter, though still almost exclusively confined to the glorification of the King's power and dignity, is more general and less individual in character than the Assyrian chronicles of history carved in alabaster. The scenes represented deal with the ceremonial life at Court, not with individual acts of prowess and heroism. Statuesque

dignity takes the place of well accentuated action, and herein may again be found the influence of early Greek sculpture. Drawing their inspiration from many foreign sources, the ancient Persians were unable to develop a really national style in art, and exercised little or no influence on the art of other races.

If our knowledge of the art of the Phœnicians, and, to a certain extent, of the ancient Hebrews, is exceedingly limited, it is probably due to the fact that neither of these two races ever arrived at a marked national style, like the races of the Nile Valley and of Central Asia. The Phœnicians are known to have been skilled craftsmen in many branches of applied art, but they confined themselves to the mechanical repetition of imported ideas. Their sculpture and architecture never rose above primitive crudeness. In the history of art they must, however, be given a certain position, because through their enterprise in trade and navigation they formed a link between the East and West, and helped to spread the civilisation of Central Asia in Europe.

The Art of the Ancient Jews. The art of the ancient Jews has left even fewer traces than that of Phœnicia, and can only be judged from descriptions in the Old Testament. The severe Mosaic law, which forbade the representation of the divine, one of the most powerful stimulants to artistic activity, held the Hebrew artists and craftsmen within strict confines. Their carved winged Kherubim and some of their architectural motifs can be traced back to Assyrian sources; the disposition of the Temple at Jerusalem is similar to the Egyptian scheme; the profuse use of gold suggests Persian influence; whilst the so-called tombs of the Kings are distinctly Greek in character.

Modern research has thrown an entirely new light on the art of Eastern Asia, the supposed great antiquity of which is now believed to be more than questionable. M. S. Reinach, in fact, points out that India had no art whatever before the period of Alexander the Great, and that China "first began to produce masterpieces during the Mediæval Ages in Europe. The most ancient Chinese sculptures of ascertained date were executed about the year 130 of our era."



Mansell

24. BLACK MARBLE OBELISK OF SHALMANESER
(From the British Museum. One of the few known examples of a free standing monument from Assyria, which did not supply the necessary materials)

Chinese Art. Whether the birth of Chinese art is of so recent a date, or goes back to a more distant past, is quite immaterial as far as the sequence of artistic development is concerned, since the strict political seclusion of the Celestial Empire has prevented the art of that country from spreading abroad and influencing, for good or for evil, the art of the West. Moreover, the art ideal of the East is so essentially different from that of the West that it can only be understood by the student who devotes himself entirely to its unravelling—and even then such understanding will be incomplete. Far greater has been the influence of the artists and marvellous craftsmen of Japan, which has permeated many phases of European art; but this influence has been of such recent occurrence that it will have to be dealt with later in connection with modern artistic tendencies.

Speaking of the art of the Far East in general, we are apt to underrate the spiritual significance, the symbolism, and the poetry that underlie what we are accustomed to consider a mere decorative convention of skilled craftsmen. But the student of Eastern ideals knows that almost every motif introduced in the decoration of a Chinese porcelain vase, or of a Japanese sword-guard, is fraught with meaning and suggestion. It is scarcely too much to say that the cultured Chinese and Japanese looks upon the manifestations of modern European art with a feeling akin to contempt. They cannot conceive why art should choose for its subject the representation of obvious facts and paltry details, since it may find a much nobler field in the expression of the inner soul of things.

Continued

THE SECRET OF LONG LIFE

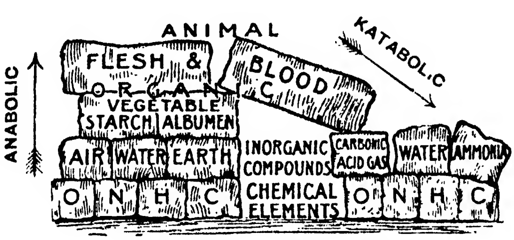
Health is Wholeness of Life. Fatigue. Forces of Destruction and Repair. Five Classes and Laws of Health. Duration of Life

By Dr. A. T. SCHOFIELD

A NATION'S health is a nation's wealth, and, what is quite as important to the individual, *your* health is *your* wealth—or a very considerable part of it.

Yet, in spite of its importance, there are few things that so defy exact definition. What is health? What is your health, and how does it differ from mine? There is no doubt whatever what it depends on; and that is *successful resistance to injury*. And there is no doubt that this successful resistance itself depends upon two factors—the strength of the attacking and of the defending forces. But when all this is said, we are as far as ever from understanding what health really is.

The Right View of Health. *Health, holiness,* and *wholeness* are words from the same root, which serve to emphasise the point of view from which this section is written. Our outlook is an essentially broad and comprehensive one; treating health and ill-health in relation to the entire man as man, and not, as is constantly the case in so many health manuals, in relation to his body alone. To say that a man is in perfect health who has a distorted mind or a distracted soul is absurd; for illness is to the body as sin is to the spirit. Therefore disease may be called sin of the body, and error or sin sickness of the soul. The man under either of these influences can be neither in a state of health nor wholeness.



THE ANABOLIC (BUILDING UP) AND KATABOLIC (THROWING DOWN) PROCESSES OF LIFE

No book, perhaps, has put this more clearly in modern days than the Giffard Lectures by Professor James, of Harvard University. The professor asserts that the health of the man consists essentially in the harmony of body, soul, and spirit, in their relations with one another and with their environment. Herbert Spencer, again, gives us the same thought when he says that health is perfect correspondence with our environment; ill-health is imperfect correspondence, while death is the result of the failure of all correspondence. Health, then, is *wholeness of life.*

Health itself is a word intelligible to everyone, but it does not mean the same thing to any two people. There are no two "healths" absolutely alike, any more than there are any two faces alike. Health, moreover, is no arbitrary standard of well-being; it is entirely a relative term and not a fixed abstraction. A cottage piano may be in perfect tune—*i.e.*, in health—but it is not a grand piano, nor ever will be; and it is for want of seeing this, and recognising our personal limitations, that our healths are often destroyed and our lives frittered away in attempting the impossible and trying to make the health standard of a "cottage" that of a "grand."

Health is Ease. One great and little understood sign of health is *physical unconsciousness.* A sentence which appears most expressive of perfect health is "Whether in the body or out of the body, I cannot tell." That is to say, that in perfect health every bodily function is performed with such entire ease that the man is unconscious of it; just as we might imagine a six-cylinder motor-car so perfect that it flies along without the slightest movement or vibration of the engines being felt by the passengers.

Much, however, that does not attain to this perfect standard is still called health; and many consider themselves quite healthy when some wheel is always creaking or some vibration always felt; for the ideal is seldom completely realised. When it is, however, it is delightful. To move absolutely unconscious of the mechanism within you, to think and live entirely without effort, is a rare experience which at times illuminates our chequered lives and is treasured up as a blissful memory.

Even natural fatigue at the end of a perfect day falls short of ideal health, in that one is then painfully conscious of tired limbs; but this may be termed a healthful ill-health, in that perfect sleep entirely dissipates it and each morning becomes a resurrection, when a new and untired body rises to obey through another day the lightest caprice of its owner. Health, therefore, is *ease* and ill-health is *dis-ease.*

Dynamic Equilibrium. Let us now look at the subject from a fresh point of view. Life is a condition of *dynamic equilibrium*—that is, a balance of the two opposing forces of destruction and repair; or, in other words, a condition of incessant change. When either of these two forces outweighs the other, the balance is lost and—in adult life, at any rate—the condition becomes one of ill-health.

The force of repair is called *anabolic* or *building up,* and that of destruction *katabolic* or *throwing down.* All life, vegetable and animal,

is balanced by these two forces; vegetable life, however, is mainly anabolic, or building up, while animal life is more katabolic, or throwing down; so that, although in human life the forces appear to be balanced, they are not really so, for the vegetable does most of the storing, while the animal does all the spending. This may be made clear by the diagram on the preceding page.

The Four Main Elements. In the diagram we see the four main elements—oxygen, nitrogen, hydrogen, and carbon—built up by inorganic nature into air, water, and earth; then further built up by the organic vegetable world into starch and albumen; and lastly by the animal one step more, into flesh and blood. In destruction, however, on the other hand, we find a sudden fall of two steps down to carbonic acid gas, water and ammonia—compounds, again, of the four elements with which we started—oxygen, nitrogen, hydrogen, and carbon. Thus the cycle of all life is complete.

Animal life is founded and depends on the vegetable. Take that away and no life is possible, for animal life cannot form flesh and blood from air, water, and earth without the intervention of the vegetable kingdom. Man, in short, cannot exist without the cabbage (as a typical vegetable), and all our vital powers are, after all, due to the silent and disinterested labours of the vegetable world.

The rapidity of the *change* by which life is characterised is very great. No less than one twenty-fourth part of the body is dying daily. We may say, indeed, that we perish faster in life than in death; the difference being that in the life the change is not seen, owing to the balancing effect of repair which is absent in death. The most healthy person must die, but the general object should be to live a healthy life and to die a natural death.

Five Classes of Health. What do we mean by a *natural death*? Men are not only born unequal in the power and capacity of their lives, but also as to the length of them. Both health and length of life are to a great extent a question of heredity. With regard to the former, Sir Benjamin Ward Richardson makes five classes:

1. The perfectly healthy. 2. The healthy. 3. The healthy till old. 4. The frequently unhealthy. 5. The constantly unhealthy.

Of this last class, he says, the average life after twenty-five is not more than fifteen years. With regard to hereditary ill-health, however, we must make one important remark, and that is that we do not inherit diseases, but tendencies to disease, which may be, and often are, successfully overcome. It is a sorry and false fatalism which declares that a drunkard's child is necessarily a drunkard. On the contrary, the glorious truth is this—that all these tendencies to drink, gout, consumption, and the like, can be not only successfully guarded against and removed if the tendency be known, but that, if thus resisted through three generations, the very tendency disappears in the fourth, and the weakened lung tissue—or digestive apparatus—with morbid craving, is absolutely and finally stamped out. To call this a "glorious truth" is not to use the language of exaggeration, for it not only delivers the individual from the "dead hand" of heredity, but it shows that by improving his own health he must benefit the future generation with cumulative force.

The Secret of Longevity. Heredity, however, shows itself not only in health, but in length of life, and it is in this that the secret of longevity mainly lies; and although this can be altered by the habits of the individual, the power to add to one's days is very slight compared to the ease with which they are shortened. Each person is born into the world with a certain life-force and is constructed to go for a certain number of years—like a clock. The length of time any individual may expect to live may be roughly calculated by dividing the sum of the lives of his six ancestors by six, and adding one year for every five that the result exceeds, or subtracting one year for every five that the result is less than sixty. Thus:

Paternal Grandfather	died at	67
" Grandmother	"	82
Maternal Grandfather	"	90
" Grandmother	"	45
Father	"	72
Mother	"	63

Sum of 6 ancestors is 419 ÷ 6 = 69 yrs and 11 months.

Failure of Life Power. To this two years may be added, as it is about ten years in excess of sixty, showing that the individual, roughly, is constructed to live for seventy-one years and eleven months. Should he so live, he then dies a natural death—that is, a death from *failure of life-power*, and not from being cut off prematurely by disease or accident. It is an astonishing thing to reflect upon that only *one in nine* in this country thus dies. We write here for the other eight, who die premature and unnatural deaths. The number of those who attain seventy years of age is in Norway one-third of the population, in England one-fourth, in France one-eighth, and in Ireland one-eleventh. It is computed that, apart from disease, the ordinary *span of life* is five times that of growth; and fixing growth at twenty-one years in the human race, men should die between 100 and 105 years. When we remember that the average duration of life here, with every advantage of sanitation, is still but forty-three years—men forty-two, women forty-four—that within our memory it was only thirty-six, that in the eighteenth century it was but twenty, we see what a mighty work remains to be achieved in perfecting the science of hygiene or prevention, as distinguished from that of medicine or cure.

It is encouraging in this connection to see what sanitation has already done. Within memory, we have seen that the span of life in this country has been increased from thirty-six to forty-three years, which means that on an average every child now born has seven years added to its life. In the seventeenth century the average span of life, instead of being forty-three, was as low as thirteen. Sanitation has lowered the death-rate in old

cities one-third, in new towns one-half. All this is encouraging, and leads us to expect still greater things.

Three Barriers Against Disease. There are three great barriers against disease—public, professional, and private.

The public barrier against disease is every year getting more efficient in our Public Health laws, and in officers who not only surround our seaboard with a line of defence it is difficult to break through, but who extend like a fine network all over our country. In the towns they are all-powerful; in the most remote village the voice of Hygiene is heard through the admirable County Council lectures which are now everywhere given.

The next great enemy of disease is the professional barrier, erected by the medical profession, and it is greatly to its honour that it has gone out of its way in the noblest manner, in numberless instances, to prevent that disease by which alone it lives.

But, as Lord Derby has so well reminded us, there exists a far greater barrier than these—the private barrier, consisting of a knowledge of the principles and practice of hygiene in the minds of the people. It is this that men long for, and it is to this end that we shall seek in the plainest and most forcible manner to give here a plain and succinct account of the laws of personal and domestic hygiene.

Our subject falls into four great divisions. The first is devoted to General Principles; the second is a close study of the Five Laws of Health; the third is devoted to Personal Hygiene; and the fourth treats of Environment in all its main aspects of work, locality, home, sanitation, and the various health laws under which we live.

The Signs of Health. It has already been pointed out that health is a most difficult matter to define, and that a man may even feel in health and yet be unhealthy. Symptoms of disease often do not appear at first; ill-health is by no means always apparent.

No one but a skilled physician can really say if a man is in perfect physical health and strength.

Dr. Southey gives as signs of health: (*a*) "Good construction, that is a sound body; (*b*) Accommodativeness to change, individual adaptability to widely diverse conditions of life, or of climate, without deterioration of energy; (*c*) Endurance; (*d*) Self-control—mental, emotional, sexual; (*e*) Resistance to morbific influences." These definitions go somewhat beyond mere health, and are rather parts of what is called *robust health,* or health and strength. He further says, "Health at every age may be securéd by following this brief advice. For infancy and childhood—*sustine* (or sustain); for adult years—*sustine et abstine* (or sustain and abstain); for old age—*sustine* (or sustain) again.

Speaking of strength we must remember that "strength" by no means always involves conditions of health. A man may be remarkably "strong" in more than one way; his muscles may be of extraordinary size and vigour, or his brain active and powerful; he may excel as an athlete, or he may be conspicuous for intellectual energy; and yet he may be in imminent danger of death from failure of some vital organ. Such a state is not a very uncommon one.

Again, as Sir William Savory has pointed out, one person will live and enjoy life in the midst of hardship and deprivation, will bear exposure and escape risks to which many others would succumb, and yet die prematurely from some cause which appears to arise from within. Another person will be throughout his life extremely delicate, never attaining enjoyment of it except at the expense of care and watchfulness, and perhaps not even then; yet living on into a good old age.

The Conditions of Long Life. But these apparent contradictions disappear when it is remembered that health and the duration of life depend on the health and power of endurance of the weakest of the organs which are necessary to it; that failure in one organ cannot be compensated by excess of energy in another whose function is different; and furthermore, that full and even extraordinary vigour of an organ during a great portion of its life does not necessarily foretell a long term of endurance. For a while it may be strong, and yet may very soon wear out. But although health and strength are by no means always associated; and although, further, health in its proper sense does not always imply a long life; yet in estimating the chances of its duration, it need hardly be said that these conditions are of paramount importance.

The health of all individuals is largely affected by their original constitution. Unquestionably, there is more of vital action in a given time in some individuals than in others. In a strictly physiological sense, some live much faster than others, and die prematurely, if life be measured only by time (which, as has been pointed out, is fallacious), but not if the amount of it may be estimated by action.

That physical state is the most promising which may be described as the average one. Exaggeration or eccentricity, or considerable deviation from the usual type, whether of the whole frame or any important organ of it, is probably not favourable in this respect; although perhaps such extreme conditions may represent extraordinary powers in a particular direction.

Disadvantages of Extremes. For example, in regard to height and bulk, very tall and large men, as a rule, do not last so long or so well as those of average stature. In proportion to their numbers, very tall or very short men are far more often badly made than men of average size—say from five feet seven inches to five feet nine inches in height, and in weight from 140 to 160 pounds. The men of the Fire Brigade may be taken in illustration of this. They are for the most part of very average size and weight; and in physical excellence, and in attributes which more immediately depend on this, it would be difficult to match

them. In the case of any particular organ, excess or defect, or any eccentricity of character, implies a corresponding want of accurate adjustment to the rest; and harmony of action is, as we have already seen, a condition of health.

So much for some conditions on which good health depends. We need not pursue this branch of the subject further, as our business is not so much to curiously inquire into all the various factors which constitute health as to examine those external conditions on which it depends, all of which are comprehended in the word "hygiene."

The *science of hygiene* differs essentially from that of medicine, in that in the former a little knowledge is not a dangerous thing, whereas in the latter it is. It is so simple to prevent an accident compared to the difficulty of repairing the damage when done. To kick a piece of orange-peel off the pavement and so prevent a fractured thigh-bone is a simple act; to set the bone perfectly when broken takes at least four years to learn.

The Five Laws of Health. There are but five laws of health for the body, and these insist that food shall be wholesome, air pure, clothing sufficient, cleanliness practised, and exercise and rest taken when needed. Too constant thought however, even about these simple laws, is not, curiously enough, the way to preserve health; for it is perfectly true that many keep well simply by being too busy to think about themselves at all. Well-meant efforts to prolong life may simply end in shortening it, by using up the nerve force in *worrying* instead of *living*.

If we consult the authorities of all time whose maxims have come down to us, we shall find that without exception they regard man as a complex being, adapted for vicissitudes rather than sameness of habits, climate, occupation, and diet. Celsus says that health is best preserved by avoiding settled habits of life, and deviating sometimes into slight aberrations from the laws of hygiene, by varying the proportions of food and exercise, "interrupting the successions of rest and labour, and mingling hardships with indulgence." "He that too long observes punctualities condemns himself to voluntary imbecility, and will not long escape the miseries of disease." Sterne says "People always taking care of their health are like misers hoarding a treasure, they have never spirits enough to spend." Many will remember the epitaph on the Italian who took too much care of his health, "I was well—I would be better—Here I am."

On the other hand, Johnson says what is not to be forgotten, that "Health is so necessary to the duties as well as to the pleasures of life that the crime of squandering it is equal to the folly." Terence says "A principal rule of life is not to be too much addicted to any one thing."

Risks of Over-anxiety. Dr. Norman Kerr used to say that a great danger lurks "in the very thinking of health"; a remark which makes one rather anxious as to the lurking danger of studying the subject at all, and indeed, this danger is a real one. It is quite possible to study hygiene, though we will take every possible safeguard against introspection, in a morbid spirit; and thus this section, which, rightly considered, cannot fail to be for the good of its readers, may be so misused by them as to turn to evil. The way to prevent this is to take heed to these warnings. "The pursuit of health," says some cynical wit, "is good, if it be not our own." If you would be healthy never make health your object. Egotism always defeats itself, and if it pursues health and happiness as *an end in life*, it never reaches it. It seems singular counsel in a treatise on health to advocate a wise carelessness, but it is profoundly true, from a reason that those who are acquainted with the subject and the wonders of the unconscious mind well know.

No engineer could afford for one moment to be in such ignorance of his engines as we are of our bodies; though the engine is a much simpler machine than the body; and yet we will take care to advocate no detailed introspection here; for the essence of health consists in knowing our duty and doing it, and not in interfering with machinery we do not understand. The fact is, I (the ego) am not the engineer down below, looking after the machinery, but the captain on deck, directing and navigating the vessel. In other words, the conscious mind uses and directs the life that the unconscious mind maintains and produces.

A Self-protective Organism. Our organism, indeed, is largely self-protective, even against external injuries, though not so perfectly as in animals; for we have reason as well as instinct to guide us, and are expected to use it.

Still, as a rule we may safely trust the unconscious mind to govern the body aright, and may generally follow our healthy instincts as to food, clothing, surroundings, &c.

Interference by the conscious mind in personal health, if frequent, tends to hinder it, not to promote it. I shall point out in detail when to interfere and when not—at present I only say that the policy of non-interference is the path of health.

In saying this, even in general terms, it must be understood that there is a wise inspection of oneself and a wise carefulness as well as carelessness. To know one's weak points, whether of heredity or habits, and to act accordingly, makes a strong man, not a weak one.

Continued

BORING FOR MINERALS

Proving Deposits. Percussive and Rotary Boring: the Tools Employed and their Use upon Different Deposits

By D. A. LOUIS

WE may first consider the mode of proving a well-exposed deposit, such as a granite bluff, or a face of stone or good outcrop of ore. Various places would be selected as the result of a good inspection of the deposit, and by any convenient means, such as pick and shovel, crowbar, jumper, gad and hammer, or drills and blasting, a quantity of the material would be broken down at each place and thoroughly examined for desirable properties. The freshly exposed surfaces would also be closely inspected to see if the material maintained a favourable character, and if all were found satisfactory at several points in the deposit, the proper preparations would then be made for the quarrying or mining operations, and the money required could be safely appropriated for the purpose.

Proving Alluvial Deposits. An alluvial deposit at the surface would be tested by digging holes in several places and by examining the material excavated to see if it were suitable for the purpose required, whether for brickmaking, sand pits, gravel pits, gold, gems, or what not. In the case of gold the pan would be used for testing purposes. Careful records would be kept of the material from each hole, the relative positions of which would be ascertained by the measure and compass, or by a proper survey, and marked on a plan. The material on *bed-rock*, especially of a gold placer, would be more particularly examined, as there the greater quantity of the gold would be accumulated. The material containing the gold, etc., is known as *pay dirt*. If the depth of the deposit were very great, boring might be resorted to or even shafts sunk and galleries driven in the deposit; and only after the material sought had been found in good quantity so as to pay for the expense of development and more would more extensive operations be contemplated. Nevertheless, at this stage such simple appliances as *the cradle* or *Long Tom* might be introduced.

An alluvial deposit at the bottom of a river, lake, or swamp would be proved by dredging operations on a small scale in different parts of the deposit; and, again, only when the results of those investigations justified it would more elaborate operations be contemplated.

The Cradle. The cradle is a wooden box in some instances about 3 ft. long and about 18 in. wide and high. It is open in the front and closed at the back, where the stuff is charged in through a removable tray with a perforated sheet-iron bottom to retain the stones. Beneath the tray an inclined canvas apron is stretched so as to direct the stream of water and material towards the back of the cradle. Across the bottom from side to side, two bars, or riffles, about ¾ in. thick, are nailed, one at the middle and one near the end. The bottom slopes down slightly towards the open end and the whole is supported on two transverse rockers which enable it to be rocked like a baby's cradle. The lighter material is washed away, while the heavier material, or at least some of it, remains in the bottom, especially behind the riffles, and is collected and panned.

The Long Tom. The Long Tom is a wooden trough about 12 ft. long and 2 ft. wide at the head, and gradually widening towards the other end, which is closed by a plate of perforated sheet-iron to stop the stones; below this is fixed an inclined wooden box with transverse riffles, behind which the heavier matter accumulates and can be further washed either in the pan or in the cradle first and then in the pan.

Proving a Vein. The outcrop would have been examined by the prospector, but whoever undertakes the proving of a vein would carefully examine the outcrop himself, and have good large quantities broken down and tested, and, moreover, would sink pits down into the vein and, if possible, drive galleries from the side of a hill in or into it, and from these investigations might judge whether further operations would be justified. It is not always possible to attack a vein in this way, as the outcrop, for instance, may be covered up.

Trenching. Trenching is employed when the ground, or *overburden*, covering a vein is quite shallow. It consists in digging trenches at right angles to the presumed strike of the vein and thereby, if possible, exposing it to view. Then several similar and parallel cuttings are made at appropriate intervals, and other cuttings can also be made in the direction of the strike until satisfactory evidence of the character of the vein at the top is obtained from an examination of the excavated material.

Costeaning. Costeaning is frequently resorted to for the purpose of proving veins. Vertical pits are sunk in each side of the supposed position of the vein or veins, and an underground communication is made between these opposed pits which, if the position has been judged correctly, will cut through the vein, and its character and contents can then be examined. Pits with communicating galleries may be multiplied to any desirable extent. These pits are sunk, if the ground be soft, by means of picks and shovels and if they be required only a few feet deep the excavated soil can be thrown to the surface, erecting, if necessary, an intermediate platform or platforms, so as to throw

it up in stages. But for any greater depth a windlass is erected over the hole and the excavated material is drawn to the surface by means of a rope and bucket. It is usually necessary to prevent loose material falling from the sides of the pit, and to do this, wooden lining is put in; this may consist of frames made of notched timber to fit the shaft, and kept any required distance apart by means of struts called *studdles.* They are held in position by supports driven into the walls of the shaft or by boards, or *stringing deals,* nailed from frame to frame in front; laths or boards or faggots—known as *lagging*—are packed behind the frames. As the ground becomes harder, jumpers or drills and explosives are used, and if the sides are of good solid rock further timbering may be unnecessary. Fig. 24, lent by Mr. R. E. Commans, exhibits the kind of surface arrangements for work of this kind. The windlass and bucket are shown and also a primitive sort of pump for dealing with water. To the left a man is shown working a small cradle.

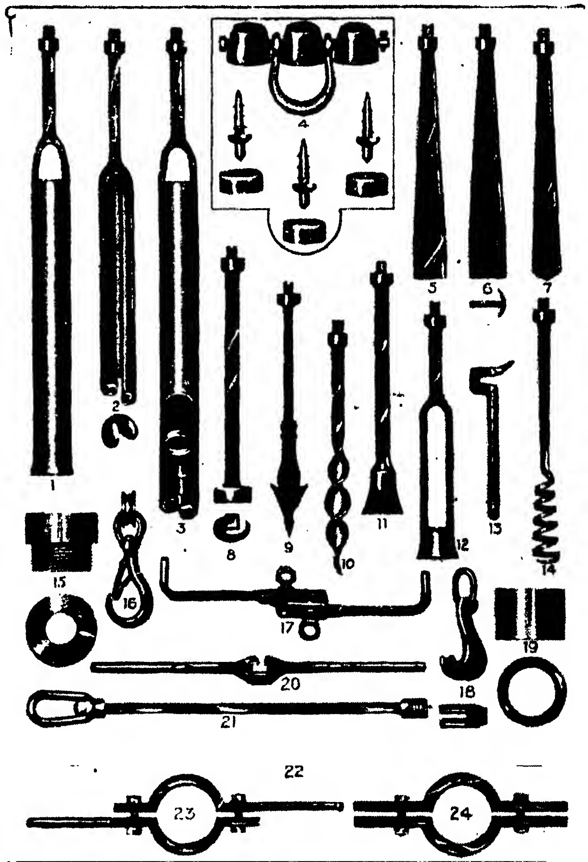
Galleries. The horizontal galleries to connect the pits are driven with similar appliances—picks and shovels, gads and hammers, or drills and explosives, as the case may be. If the ground be loose it has to be timbered. Here, again, a framework is erected at intervals and lagging packed in overhead and up the sides The parts of the frames are known as the *cap, the legs,* and *sole piece;* when the ground is weak all round, all are required; when the ground in parts or all over is strong enough to stand, one or more of the parts or the whole lot may be dispensed with. A wheelbarrow running on a plank is used to convey the broken material to the bottom of the shaft.

Beds and seams may also be examined for useful deposits in a similar manner by driving trial *tunnels* or *headings* in the way described; or by sinking trial pits or shafts along the outcrop.

Useful Deposits. Any deposit, whether vein, mass, or bed, is considered useful when it contains marketable mineral in sufficient quantity and under conditions that would render its removal from the ground adequately remunerative.

Where vein deposits or masses are supposed to exist, but are more or less deeply buried in the earth, or where a stratified deposit lies hidden beneath so much overburden that it would be too costly and too inconvenient to sink shafts or to costean for purposes of verification, it is then customary to bore a hole and so to investigate by the examination of the borings extracted from the hole the character of the materials that exist between the surface and the deposit as well as that of the deposit itself. Moreover, by this means, when the deposit is reached, its depth below ground is also ascertained by measuring the depth of the hole.

Boring. *Boring* is an important adjunct to mining. It consists in making a long hole in the ground with suitable implements. This hole may be made in solid rock by a process similar to drilling—that is, by giving blows on the bottom of the hole and so chipping away the rock and clearing out the broken stuff from time to time; this is *percussive boring.* A hole may also be bored in solid rock by means of cutters set in a ring, which, when given a rotary motion, make an annular cut in the rock, leaving a column of rock standing in the centre of the hole; this column of rock is called the *core,* which is broken off and brought to the surface. This is *rotary boring,* and a variant on this is used for penetrating plastic material, for which purpose an auger-like implement is used; but, for penetrating

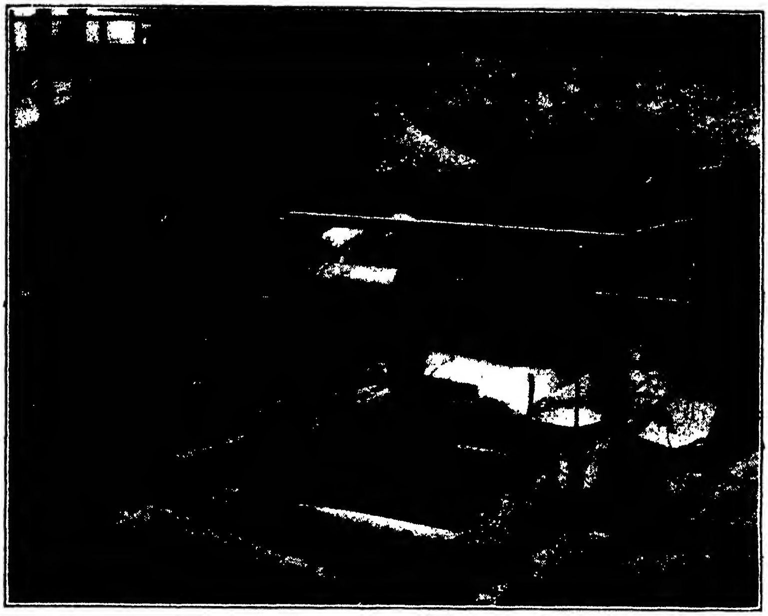


23. PERCUSSIVE BORING TOOLS

1. Shoe-nose shell for gravel, sand, etc. 2. Clay auger for clay or stiff earth 3. Auger-nose shell with valve for saturated soils 4. Ironwork for wooden shear legs 5. Flat chisel for soft rocks 6. T-chisel for harder rocks 7. V-chisel for moderate rocks 8. Crowsfoot for drawing broken rods and tools 9. Spring dart for drawing out pipes 10. Worm auger for loosening material in boreholes 11. Bell screw for extracting broken rods 12. Bell box for extracting broken rods or tools 13. Hand dog or rod wrench 14. Worm for drawing broken rods 15. Driving cap for top of casing tubes 16. Spring hook 17. Tillers for turning rods 18. Lifting dogs for raising rods 19. Steel driving shoe for bottom of casing tube 20. Tillers for turning rods 21. Swivel-top rod for attachment of rope 22. Square boring rods with screwed ends 23. Pipe tillers for casing tubes 24. Pipe clamps for casing tubes

loose surface material, a pipe furnished with a cutting edge is forced down into the ground, the material being cleared out from the inside of the pipe after every few feet of sinking.

Holes may be bored any width, but large holes are costly, so for testing purposes holes are bored about an inch or two in diameter. A deep hole, one going 1,000 ft. or more, would be made wider than one going only a few hundred feet or less. But holes have been bored up to many feet in diameter, under special circumstances, to which reference will be made later.



Wilson

24. EXPLORATORY SHAFT IN AUSTRALIA

Difficulties of Deep Boring. The depth of holes is restricted by cost and inconveniences which make boring, with present-day appliances, at a depth a very slow and wearying job as well as expensive. The deepest hole in the world was put down by the Prussian Government at Paruschowitz in Silesia; it reached a depth of 6,572 ft. in 399 days, the last 3 ft. taking three months of the time. It was started with a diameter of 12 in., and finished $2\frac{3}{4}$ in. in diameter; the weight of the rods, in spite of their being made of steel, was $13\frac{3}{4}$ tons—in fact, it was the breaking and jamming of the rods that brought the work to an end. It cost £3,761. More recently a hole has been bored near Pittsburg, in the United States, to a depth of 6,000 ft., and over 6 in. in diameter, by the rope method in vogue in that country. The tools used were of the ordinary size, while two cables spliced together were employed to obtain the desired length and strength without undue weight. The lower cable was $2\frac{7}{8}$ in. in diameter, and weighed 8,400 lb.; the upper cable $2\frac{1}{4}$ in. in diameter, and weighing 5,600 lb. The hole cost £8,000. These examples show that deep boring is a serious undertaking, and can be contemplated only for very urgent reasons.

Uses of Boring. The uses of boring in mining are numerous, for, in addition to its applications in prospecting and for the purpose now under consideration—that of proving a property—it is frequently adopted for other purposes. For instance, boreholes are used as wells for obtaining water, petroleum, brine, mineral waters, etc.; they are used to obtain gases, such as natural gas and carbonic acid gas. They are used in mines, as vents for dangerous gases, as a precaution against explosions, to tap lodgments of water, and so prevent drowning the mine, to test the ground ahead, to search for faulted parts, to provide passages for conveying signal wires and to transmit power by water, steam, wire-rope, or electricity underground; to provide channels to convey below sand and water or cement grouting, etc., to fill up cavities left underground by the mining operations. Quite recently boreholes have proved invaluable for conveying air and food to miners imprisoned underground by an accident. These are some of the applications of boring which, moreover, has even been applied to shaft sinking. It is a vast and varied subject, but a good idea of it will be obtained from examples of small boring, medium boring, and large boring practice.

Percussion Boring Tools. For percussive boring on a small scale for 50 ft. or so, the following equipment, selected from the list of Schram, Harker, & Co., would suffice.

One set of ironwork for wooden shear legs, consisting of top caps and shackle, bottom spikes and collars
One 1-sheave pulley block
One 2-sheave pulley block
100 ft. best hemp rope
One $4\frac{1}{2}$-in. clay auger
One $3\frac{1}{2}$-in. clay auger
One 4-in. shoe nose shell
One 3-in. shoe nose shell
One $4\frac{1}{2}$-in. flat chisel
One $3\frac{1}{2}$-in. flat chisel
One $4\frac{1}{2}$-in. T-chisel
One $3\frac{1}{2}$-in. T-chisel
One worm auger
One bell screw
Two lifting dogs
Two hand dogs
One pair of tillers
One snatch block
Five 10-ft. lengths square boring rods
One top swivel rod
One spring hook,
30 ft. of rope
One auger board
One auger clearer
Two pairs casing clambs
One steel driving shoe
One driving cap
One 200-lb. monkey

Most of these are illustrated in the group of tools [23].

The Use of the Tools. A suitable site is selected for the borehole, the ground made level, and a derrick or shear legs with windlass below and a pulley at the top is erected [25]. A rope from the windlass passes over the pulley, and by means of a spring hook a swivel or swivel-top rod serves for manipulating the tools.

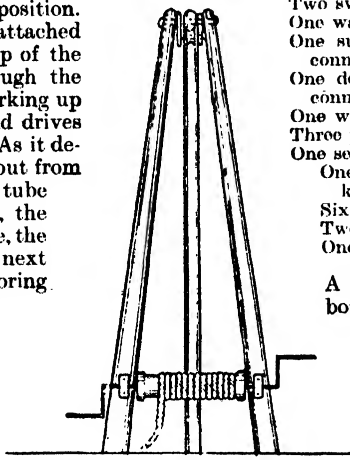
The method adopted for boring is as follows: In soft ground a clay auger is first used, for which purpose the tillers are fitted to the square shank, and slowly revolved, care being used to keep it in a perfectly vertical position. When the auger is full, it is withdrawn and the contents cleared out, and the operation repeated to the depth of a few feet. The steel cutting shoe is then screwed to the bottom of one length of casing tube, the driving cap screwed to the top end, and the tube lowered into the hole in a perfectly upright position. The driving monkey [26] is then attached to the rope coming from the top of the derrick, its stem passed through the driving cap; it is caused by jerking up to rise and fall alternately, and drives the tube down the borehole. As it descends, a little extra rope is let out from time to time. As soon as the tube has been driven sufficiently far, the monkey is detached from the rope, the driving cap removed, and the next size clay auger is attached to a boring rod and put down the borehole.

The operation is repeated until the firmness of the ground renders the rotary boring difficult. A light steel chisel is then screwed to a sufficient length of boring rod, the swivel rod fixed on the top, and an up-and-down motion is imparted to the tools, which are also slightly turned by hand so as to strike in a different position at each stroke. While this is going on, water is poured down if necessary, and the debris converted into sludge, which is afterwards raised by a sludger, provided with a valve in the lower end for this purpose. This sludger is attached directly to the rope, or boring rods as the case may be, and lowered to the bottom of the borehole. If the sludge be too thick to enter the sludger readily, it is raised and dropped a few times, which ensures its being filled. When once filled it is raised as quickly as possible to avoid leakage. Casing tubes are put down the hole until the rock is encountered, when it is generally unnecessary to line the hole further.

The heavier chisels are used for the harder rock in the same way as the lighter ones are for clay, sufficient boring rods or a boring bar being used in conjunction to give the necessary weight.

Rotary Drilling on a Small Scale. Harker's hand-power diamond boring equipment for this purpose comprises a portable engine, mounted on strong wrought-iron frame, with two fly-wheels, and the following accessories:

Steel boring rods and couplings for the specified depths
One crown set with best black diamonds
One short core tube.
One long core tube
Two core lifters (or core catchers)
Three core breakers
Six spare unset crowns
One sector rod grip, for raising or lowering rods
One drill rod hoister, with improved ball clip
One set of ironwork, for wooden shear legs
One 2-sheave pulley block
One 1-sheave pulley block
100 ft. hemp rope
One swivel eye bolt to screw into boring rods
One chuck for holding crown in vice when setting diamonds
One bench vice
One drill support
One swing brace with two chucks
Six drill bits, for use with above
One hand vice
One box cement
One hack saw with two blades
One water pump, complete
One press for making plunger leathers
Two swivel connections to boring rods
One water strainer for suction hose
One suction hose, 15 ft. long, with brass connections
One delivery hose, 30 ft. long, with brass connections
One weight suspender, with weights
Three pairs tongs for rods
One set spanners
One set tommy keys
Six assorted files
Two pairs callipers
One hammer
One screw hammer.
One oil-can.
One spirit level.
One plumb bob and line.



25. BORING SHEAR LEGS WITH WINDLASS

A suitable site is selected for the borehole, the ground is made level, and derrick, etc., put up. Strong timbers (both longitudinal and crosswise) are laid down, and to them the frame of machine is bolted, and any other means taken to give rigidity and to prevent any movement of the machine that would cause the borehole to get out of truth. The rods A [27], core tube, and the diamond crown [28] are screwed together, and the crown and rods gently lowered until the crown rests on the surface of the ground; the rod is not allowed to drop on to the rock, as this would shatter the diamonds. It is most important to bear in mind that, although a diamond is the hardest known substance, and will stand an almost unlimited amount of abrasion, yet a comparatively slight blow will smash it. The crown is raised an inch off the ground, the machine slowly revolved and the boring rod got perfectly into line. The water swivel is then screwed to the top of boring rod, and the hose B connected up to the pump C, water-tank, or other suitable water supply.

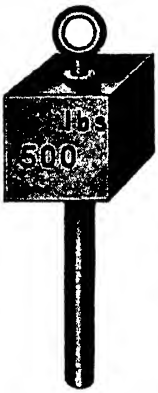
Boring is started very gently until half an inch has been bored, after which it is run more vigorously. In the illustration, D' is a counterbalance to reduce the weight of the rods. When the rack reaches its lowest point, additional lengths of boring rods are added as required.

To withdraw the boring rods from the borehole when the core tube is full, or for any other reason, the boring rods are uncoupled between the gear and the top of the borehole. The

water attachment, etc., disconnected, the rod grip is slipped over the lower rods down to the surface of the borehole; the swivel eye bolt is screwed into the boring rods projecting from the borehole and the hoisting rope is attached. The rods are then raised and the successive lengths uncoupled, the rod grip preventing the rods from falling back into the borehole.

When the core tube reaches the surface it is emptied of its contents, the diamond crown is inspected, and any loose stones caulked up [28]. The stones appear as black spots in the figure.

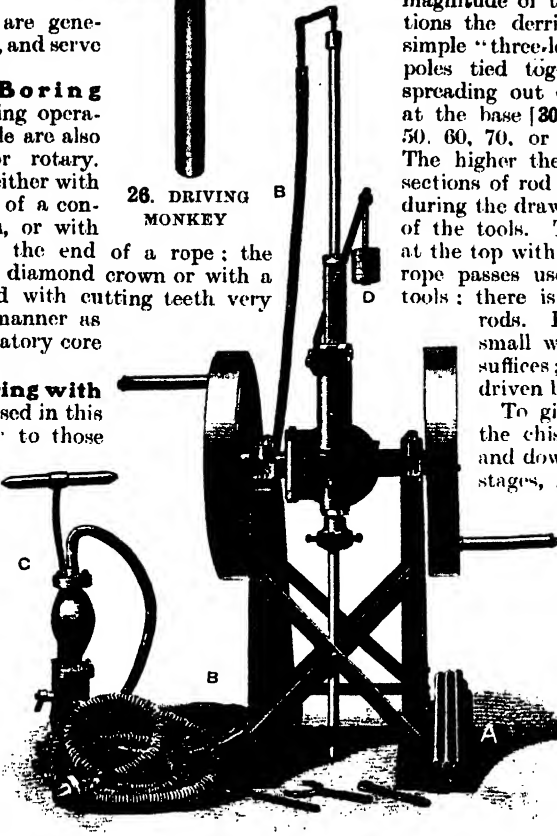
These appliances are generally worked by hand, and serve for exploratory work.



26. DRIVING MONKEY

Extended Boring Operations. Boring operations on a larger scale are also either percussive or rotary. The former is done either with the cutter at the end of a continuous line of rods, or with a string of tools at the end of a rope; the latter is done with a diamond crown or with a steel crown provided with cutting teeth very much in the same manner as in the case of exploratory core boring.

Percussive Boring with Rods. The tools used in this operation are similar to those used in the smaller operations: *chisels*, *rods*, *bracehead* or *tiller*, *augers*, *sludgers*, *keys* for screwing and holding the rods, *tubes* for lining, and several tools for dressing the side of the boreholes, and for extracting obstructions such as broken rods.



27. HARKER'S HAND-POWER DIAMOND BORING MACHINE

Chisels are made of the best steel, flat ones with straight cutting edges being the most common, but other shaped edges such as V and T are used to suit certain rocks. They vary in size to suit circumstances, 18 to 24 in. length, 1 or 2 in. thick, and 2 in., 3 in., or 4 in. face being ordinary dimensions. They taper towards the top, terminating with a shoulder or boss and a screw. Rods are sometimes of wood, but usually of the best wrought iron, an inch square being a common size; they are made in lengths of from 18 in. up to 20 or more feet, and in all cases they terminate with shoulders provided with a screw socket at one end and a projecting screw at the other, so as to enable them to be screwed together to form a continuous line of rod. The lowest rod is attached to the chisel and the uppermost rod to the arrangement known as the *bracehead*, which consists of a short length of rod, with a socket at the top, into which four horizontal wooden arms fit, and at the top of the bracehead there is a swivel. The tiller replaces the bracehead as holes deepen, or sometimes altogether. And between the bracehead or tiller and the lever or spring pole there is an arrangement which will allow the chisel to progress downwards without perpetually stopping to put in fresh lengths of rod; and this arrangement is *the stirrup*, which consists of a bridle of iron with a long screw working in it.

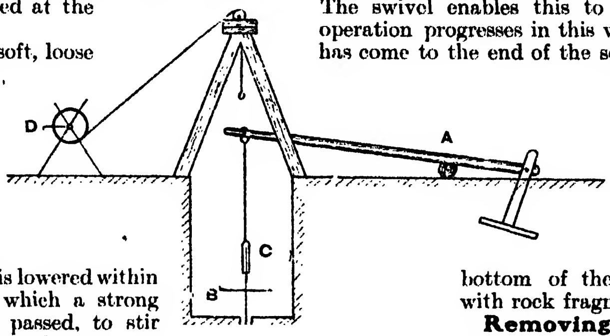
The Derrick. In accordance with the magnitude of the contemplated operations the derrick may vary from a simple "three-legs" consisting of three poles tied together at the top and spreading out over a triangular area at the base [30] up to a frame tower 50, 60, 70, or even more feet high. The higher the tower the longer the sections of rod that can be dealt with during the drawing up or letting down of the tools. The derrick is provided at the top with a pulley over which a rope passes used in winding up the tools; there is also a guide for the rods. For winding purposes in small work, a hand windlass suffices; for larger work a drum driven by an engine is required.

To give the necessary blow the chisel has to be lifted up and down, which, in the early stages, is done by hand, while for moderate depths the *spring pole* suffices. The spring pole consists of a long pole fixed to the ground at one end, resting on a fulcrum about one-third the whole length from the end, while the other end is free and furnished with a hook. The diagram [29] shows a spring pole at work, B the tiller, or bracehead, C the stirrup, D the windlass. A pit as shown is frequently used in boring to give more headway, and to protect the workers. In more extensive borings the spring pole is replaced by a *rocking lever* or *walking beam*, the tools, etc., being attached to the shorter arm, while the other arm gets a vertical reciprocating motion from an eccentric or even an engine. The operation of

28. BORING CROWN SET WITH DIAMONDS

boring on the larger scale is very like that already described, but a wooden platform some few feet square is laid on the ground with a hole bored in the centre for the rods to pass through into the borehole, or a *guide* block of heavy timber is fixed at the surface.

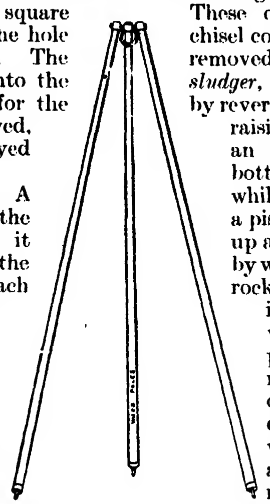
To bore through soft, loose ground, a pipe, furnished with a cutting edge, and called a *drive pipe*, is used. It is driven into the ground by letting a heavy block fall on it, while a second pipe of smaller diameter is lowered within the other, through which a strong stream of water is passed, to stir up the loose material near the cutting edge and carry it to the surface. Usually, however, some more serious operation is demanded, and the place of the drive pipe is taken by a guide pipe, of iron or of wood, which is driven down 6 ft. or 9 ft., and has a hole of the same diameter as the borehole. Fig. 33 shows a method of driving with the ordinary tackle. The *maul* is attached to a length of rope, and works in guides, not shown, and is caused to rise and fall and strike the pipe by means of the connection with the crank B attached to a pulley. The drive pipe is fixed truly vertical, and is provided at the top with iron shutters turning around pins so that they can be moved away when required. They have a square hole in them over the centre of the hole to allow the passage of the rod. The shutters prevent anything falling into the hole, and also they supply a rest for the rods while they are being unscrewed, although usually a *fork* or *key* is employed for the purpose.



29. BORING TACKLE WITH SPRING POLE

Boring in Hard Ground. A couple of men screw the chisel to the end of a short rod, and, putting it through the guide pipe, strike on the ground, turning it round between each blow. When half a yard is tried, the bracehead is put on to enable them to lift and turn the rods more easily. They take off short rods and substitute long ones, then adding short ones, and again substituting every half yard, so as to keep the bracehead at the most convenient height for handling. When the length of rods gets too great for three or four men to lift with ease, the spring pole, rocking lever, or other means of balancing the weight is brought into requisition along with the stirrup. These all being in adjustment, the rocking lever is set to work giving a blow each down stroke of the short arm, or the spring pole is pressed down to give the blow, its elasticity doing the work of lifting the rods and chisel. After each stroke, the workmen at the bracehead still give a turn of about one-eighth of a circle to obtain a round hole by making the chisel hit a different place each successive time. The swivel enables this to be done, and the operation progresses in this way until the bridle has come to the end of the screw of the stirrup, when a stoppage is made to put in a suitable length of rod between the bracehead and the top rod and to run up the screw. Then the operation is continued until the bottom of the hole gets choked with rock fragments.

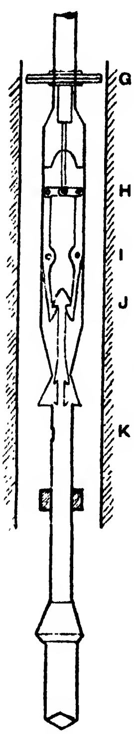
Removing the Broken Stuff. The boring is then stopped, the bracehead, etc., unscrewed, the rope from the windlass or winding arrangement run down and hooked to a cap provided with a ring and screwed into the top rod; or a dog or claw, which is passed under the shoulder of the rod, is used instead. As great a section of rod as the height of the derrick will permit is drawn up by the windlass, the cover of the guide pipe is closed, and the shoulder of the last rod that has passed through is allowed to rest on this cover or the fork thrust over the cover; then the upper lengths of rod are unscrewed in one long section and stacked out of the way. These operations are continued until the chisel comes to the surface; it is in its turn removed and replaced by a *sand-pump* or *sludger*, which is lowered down into the hole by reversing the operations of unscrewing and raising the rods. The *sludger* consists of an open iron cylinder, closed at the bottom by a valve opening upwards, while the sand-pump has, in addition, a piston and rod. It is vigorously jerked up and down in the bottom of the hole, by which means the fragments of chipped rock are caused to enter the cylinder, in which they are retained by the valve. When the sludger or sand-pump has collected the waste, it is raised to the surface and emptied, the chisel again screwed on and lowered down to do its chipping in the usual way. The contents of the sludger are carefully examined each time, note being taken of the character of the rock, the occurrence of fragments of fossils and minerals, and particularly the presence of any useful minerals, all observations being recorded along with the depths to which they refer.



30. LIGHT WOODEN BORING DERRICK

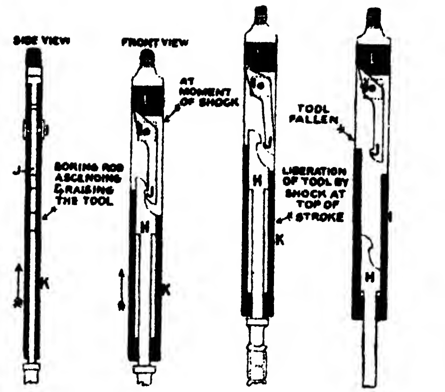
Weight of the Rods. In deep boreholes, the jar caused by the weight of the falling column of rods becomes a very serious matter, liable

to lead to fracture; hence, *hollow rods* have at times been used to reduce this weight, but have been found expensive. *Wooden rods*, for the same reason, have enjoyed a great vogue in Canada and in Galicia. They are larger—2 in. or 3 in. square, and 20 ft. to 30 ft. long—than iron rods; they are specifically lighter; they displace more water in a wet borehole, and greatly reduce the falling weight and liability to fracture. Wooden rods are particularly applicable where iron rods are not easily obtained. Generally, however, what is known as a *free-fall* appliance is interposed between the upper line of rod and a lower section to which the chisel is attached. Some of these appliances at the commencement of the down-stroke of the rods release the section of rod with the chisel attached, which falls rapidly by gravity, and gives the blow without any shock to the upper line of rod, which follows at a less rapid rate, reaches the fallen section, and at the commencement of the up-stroke grips it so that it follows up until released by the reversal of the stroke.



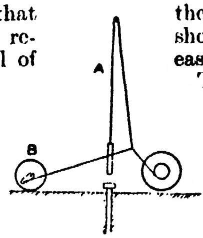
31. KIND'S FREE FALL APPLIANCE

Free-fall Appliances. Fig. 32 shows Arrault's free-fall arrangement. The chisel is suspended from the catch H. The catch J is supported on a pin in an oval hole. On the up-stroke the rocking lever strikes a bumping-piece and stops suddenly with the rods, but inertia causes the catch J to continue its upward movement; it strikes an inclined surface L and releases H, which with the chisel falls ahead of the rest of the rods, but H hooks itself on again as soon as J reaches it. Kind's free-fall arrangement is shown in **31.** The lower length of the rods with the chisel is attached to K, at which it is gripped by the jaws I. These are pivoted at 1, and by means of links at H and a rod are



32. FREE FALLING TOOL LIBERATED BY REACTION

connected at the sliding disc G. The latter is held down by the water in the hole while the main rods are ascending, but as soon as the stroke is reversed it is lifted by the resistance of the water, opens the jaws J, and releases the chisel, which makes its blow without shock to the column of rods, and the jaws easily pick K up again.



33. METHOD OF DRIVING STAND-PIPE

The sliding joint is used to achieve the same object. It consists of a bridle and collar, and is interposed in the line of rod; the whole line rises together, the shoulder of the top rod of the lower section resting on the collar, and also falls together until the chisel and its section is arrested by striking the bottom of the hole, but without any shock to the upper part, which continues the down stroke, inasmuch as the collar slides over the stationary lower rods until progress is arrested by an elastic stop placed beneath the rocking lever at the surface. On the up-stroke, the movement of the collar is reversed, and on reaching the shoulder it picks up the striking section of rod again. There are, however, many patterns of free-fall appliances, and their use has greatly reduced accidents due to fractures of the rods. But obviously the best way of eliminating the weight and other inconveniences of the rods is to use something else, and when conditions are favourable this is done by the use of a rope, which, moreover, works well in regular country.

Continued

Group 17 **APPLIED EDUCATION** 8 Continued from page 2580	# THE USE OF TIME **Arrangement of the Working Day. Recreation and Amusements. Nervous Force Economised by Habit. Time and Brain**

By HAROLD BEGBIE

IT is now pretty generally recognised among medical men that the day divides itself into three parts naturally suited to: (1) Mental labour; (2) physical recreation; (3) light amusements. The morning is recognised as the natural period for mental labour, the afternoon as the natural period for physical recreation, and the evening as the natural period for light amusement.

Without some such general plan as this, it is difficult to see how a man can effect that economy of time which is the beginning of wisdom in earthly business. There must be some broad and general principle in the matter.

Morning the Time for Mental Work. "From the time when I was old enough to feel rationally accountable for the use of time and the economy of mental power," writes an American author, "it has been my custom to devote the early part of every day—say, from eight or nine o'clock till one or two o'clock—to serious mental work. The afternoon was given to exercise, recreation, and social intercourse. No severe employment of the brain was pursued late at night or far into the evening. Not half a dozen times in my life have I studied or toiled till midnight. In order that sleep might be quiet and refreshing, the brain was allowed to cool, and the blood encouraged to circulate evenly through the frame."

It is essential to remember that the brain is unable to bear any severe strain immediately after a meal. The blood, which is required at such a time to do the difficult and most important labour of digesting food, cannot at the same time quicken the cells of the brain to nervous activity. It is therefore necessary so to arrange the order of one's life that the chief work of the brain may fall at a time of the day when the body is least clogged with food.

Given such a general principle as we have referred to, the matter of the management of time presents itself in a fashion easier of apprehension. The question then becomes: How may I so order, first my study, then my recreation, and then my amusements, as to get the most out of them in the time at my disposal? The student is, as it were, able to deal with his time by compartments.

The Careful Planning of Work. As soon as he perceives that in devoting the morning to study he is giving the best part of his day to this end, the student will be particularly jealous of interruptions. One of the best means for the prevention of wasted time is a locked door. The brain, when once it has been set moving in any particular direction, travels at an increasing pace, so that the latter half of a morning's work contains usually twice as much virtue as the first. It will, therefore, be seen that any check in the momentum of the brain, any interruption of the flow of the machinery, means not only a loss of time during the enactment of the interruption, but a very considerable loss of time in once more "getting up steam." Time is saved by protecting it from filchers and pilferers. The chief pilferers are the scarce noticeable interruptions of a normal household. The student must, of course, so arrange his studies as to suffer as little as possible in loss of time by going from one particular study to another. It will be found that one study helps another, and that it flows naturally on with something of the same interest into another, and in these cases time is saved by arranging for these studies to run successively. For instance, the brain can take up the threads of history with greater ease after dropping the threads of literature than after dropping the threads of mathematics.

The Thieves of Time. Much time is wasted in unsuitable recreations. Many people believe that any game is good enough for physical recreation, and take no trouble in their selection. A little thought, however, will soon convince the inquirer that there are certain forms of exercise which suit him far better than others—that is to say, particular exercises after which he feels a keen refreshment of mind and body. To play an arduous game, irrespective of its effect upon the mind and body, in the simple faith that any exercise must be beneficial, is seriously to waste time. The game which exhausts the mind is as bad as the study which tires the brain, and the game which educates no virtue and brings no useful quality into action, is a thief of time. Every game should contribute to the joy and spring of existence.

In no other division of his day is a man so likely to waste time as that which he sets apart for light amusements and social intercourse. A contemplation of the subject suggests a volume rather than a paragraph, and we can only afford to name a few heads under which the reader will see for himself how easily time can be wasted—frivolous conversations, inane plays, stupid music, senseless parties, trivial games, meaningless hobbies. When it is remembered that nervous energy can be as greatly exhausted by a stupid conversation as by an absurd game, and when it is remembered that the condition of the atmosphere in most places of amusement is an active consumer of force—paralysing effort on the following day—it will be seen how very easily time may be wasted in an innocent

but thoughtless manner. Mr. John Morley has said that he does not mind wasting his time, but he resents having his time wasted for him. Most people in their amusements submit themselves placidly to this latter process.

Wasted Force. A good conversation is a mental tonic; a foolish conversation is a poison. The chief consideration in this matter is nervous energy. Each man is supplied with a certain amount of this force, and how he utilises it is to all intents and purposes synonymous with his use of time. He may either employ his nervous energy wisely and scientifically, getting out of himself all that is possible, or he may fritter and gamble away this priceless energy, losing every opportunity for his personal advantage. A consideration of this nature ought to be sufficient warning for those who sing, dance, laugh, and play strenuously, believing that so long as one is making a great noise, and growing thoroughly excited, the body is refreshing itself in a brilliant fashion. It is also a warning for those who believe that they can put an extraordinary amount of energy into some serious undertaking on one day, and not suffer for it on the next. The use of this energy is the first step in the management of time.

But before considering how he shall divide up his time, and by what persuasions he shall be guided in his selection of employments, it is necessary for the student to have clear cut and certain before his eyes the final objective of his existence. At the root of how much unhappiness, defeat, and misery is the aimlessness of conscience? To have no definite aim, to keep before one no certain goal, to cherish in one's heart no absolute and crowning ideal, is infallibly to botch the business of life.

To What End are We Moving? It is not enough for a student to know that the reason for his studies is triumph in a particular examination, not even to be assured that his studies are inspired by the pure pleasure of knowledge; no, he must have a reason beyond these reasons, the ultimate and determining reason—the object of his existence. He has before him an uncertain number of hours, with death certain at the end. An examination is merely a mile-post, an employment is merely a means of transit, pleasures are but hobbies on the road. The question of questions is, *Quo vadis?* To what final end is he struggling?

Happy is the man who perceives his object with clear eyes, for when once that central, that final, that all-embracing object is perceived, the management of time becomes an easy and a cheerful operation. Let us say that a man's object is religion—that is to say, devotion to the Creator for love of Him, and the perfecting of himself for the benefit of the human race; or that his object is wealth, the amassing of a vast fortune for the heirs that come after him—whatever it be, the goal once apprehended and once greatly desired, everything is made to conform to its attainment. The day's work tends to that end, the day's relaxation, the life's hobbies. Acquaintances are made, friends are attained, solely to further the grand aim. Nothing is slipshod, nothing haphazard, nothing patchwork. Every fragment of the mosaic has its place in the scheme, every thread in the pattern its sympathy with the purpose. Not an hour is wasted, not a word thrown away; his work, however harsh on the surface, is sweet to him because it is twisted to his purpose. The man knows what he is after, and by whatever paths he seeks it, and with whatever weapons endeavours to capture it, strives for the object of his desire. His whole life is a unity, every hour a rhythmic movement, every minute a pulsation in the regularity of his purpose.

Regularity the Master-Word. Regularity is the master-word in this matter. An American doctor says: "There should be regularity as regards the time of meals, the time and amount of action, the time and amount of sleep —regularity in everything. It is very difficult indeed to obtain it. But there is in our nature more power than we know, and if we conform ourselves to the law of habit, things will soon go on without our meddling with them, and we come to be perfectly regular, although we perhaps had naturally a tendency quite the reverse."

The law of habit is a most useful auxiliary in the management of time. To get by patient experiment a pattern day—a day in which we work with ease and refresh ourselves without fatigue—and to struggle to repeat that day again and again until its arrangement becomes with us a second law of Nature, is to become in the best sense of the phrase captains of our time and of ourselves. The habit of attending to trivial things, says Thoreau, can permanently damage the mind. Equally, the habit of attending only to essential things can permanently benefit the mind.

Use of Time is Use of Brain. "Amid all our speculative uncertainty," says Professor Tyndal, "there is one practical point as clear as the day—namely, that the brightness and the usefulness of life, as well as its darkness and disaster, depend to a great extent upon our own use or abuse of that miraculous organ, the brain."

We make use of this quotation at the close of our remarks to emphasise that the use of time is in reality the use of the brain.

Miss Frances Power Cobbe declared her faith that "for one woman whose health is injured by excessive study (that is, by study itself, not the baneful anxiety of examination superadded to study) there are hundreds whose health is deteriorated by want of wholesome mental exercise." Wasted time is wasted mental energy, and wasted mental energy is wasted life.

Every man should learn to regard time as the regulator of his brain, and so set it as to secure for himself the most profitable and enjoyable study, the most refreshing and delightful exercises, and the keenest and least fatiguing amusements. As he regulates his time so will his brain act, and in the healthiness, the activity, the vigour, and the alertness of his brain lies the compass of his happiness and the bounds of his achievement.

Continued

GROWTH OF ENGLAND'S LIBERTIES

Reign of William Rufus. The King and the Barons. The Crusades. Accession of Henry I. His Marriage with Matilda. The Royal Charter. Stephen

Continued from page 2611

By JUSTIN McCARTHY

WE have followed the development of England's history to the close of William the Conqueror's reign. William was succeeded in 1087 by his third but second surviving son, another William, known as William Rufus. The late sovereign's eldest son was Robert, Duke of Normandy, but on the death of the Conqueror William Rufus was at once created King by the party then dominant in England.

William Rufus. In those days the rigid rule of succession according to date of birth in a Royal family had not become such a settled institution as in a later age, and it was not unusual that on the death of a sovereign a younger son, even although not recommended by his father to the succession, should, if he had made himself popular, be raised to the throne. Many of the Norman nobles in England refused to accept the election of William Rufus, and rebelled against him in support of his elder brother Robert. Rufus appealed to the people to support him, and made them promises of liberal reforms, relief from over-taxation, relaxation of the forest laws and mitigation of parts of the Feudal system, which bore heavily on the general population—he conducted himself, in fact, much after the fashion of a modern candidate for a seat in Parliament.

The rebellion of the nobles proved a failure, and was suppressed, but William Rufus did not keep the liberal promises he had made in order to secure national support.

Wars and Invasions. During his thirteen years' reign he engaged in many wars. He made war upon his brother Robert in Normandy, but after fruitless warfare a peace was concluded, and the Duchy of Normandy was mortgaged to William. His reign saw several invasions of Northumbria by Malcolm, King of Scotland. Malcolm, who succeeded to the throne after the fall of Macbeth, seems to have been ambitious of extended power, for he invaded Northumbria more than once during the life of William the Conqueror. The boundaries of Britain and Scotland in the north of the one country and the south of the other were at that time not very clearly recognised, and Malcolm's attempts to spread his domain into North Britain were not events without precedent. William Rufus made three warlike expeditions into Wales, but failed in two of them.

The reign of William Rufus was remarkable for its struggles against the Barons, who supported the claims of Robert of Normandy, over whom William triumphed in the end; and also for its struggles against some of the most powerful prelates of the Church, then the Church of Rome. His death remains one of our historical mysteries. He was hunting in the New Forest in August, 1100, and there was killed by a wound from an arrow. There were at the time none of his courtiers or companions about him; he had ridden far into a glade of the forest, and there his dead body was found by some peasants with the arrow still sticking in the wound. Two stories were in circulation as to the cause of his death—one that the arrow shot was an accident in a forest then ridden over by many hunters; the other that he was done to death by an enemy. His remains were laid to rest in Winchester Cathedral.

The Crusades. At the time of Rufus's death his elder brother Robert was on his way home to England from the Holy Land, where he had taken part in the first Crusade. The Crusades were then occupying the attention of Europe and Asia, and, indeed, of all that part of the world which knew enough of passing events to take any interest in the movements of armies. The object of the Crusades was to drive the infidels from Jerusalem and take possession of the Holy Land. Jerusalem was then held by the Saracens, and the Crusades had been originated by Peter Gautier, called the Hermit, who, after long sojourn in Palestine, had succeeded in prevailing on Pope Urban II. to promote a great movement for the expulsion of the infidels from the land where Christ had lived and taught the doctrines of Christianity. A council was held by Urban's summons at Claremont in France; the ambassadors of all the Christian sovereigns were present, and an appeal was made to Europe for a general war.

The Crusades made an important epoch in history, in romance, and in poetry. They awakened the enthusiasm of all the Christian States and peoples, and for many years the great ambition of every rising soldier, whether the son of a reigning sovereign or of a lowly peasant, was to take part in the effort to recover for Christianity the possession of the Holy Land. For nearly two centuries the Crusades were maintained. Jerusalem was taken and retaken by the Christians, and at length recaptured by the infidels. King Edward I. of England, when Prince Edward, took a part in the last Crusade. Finally the Soldan, the Saracen sovereign, gained the upper hand, and the Christians were driven out of Syria.

The Growth of Popular Power. Robert of Normandy was returning from the first Crusade when the death of William Rufus took place. But in the meantime his younger brother, Henry, not only claimed, but actually insisted on, the succession as his own. The

Barons strongly opposed this claim, and maintained the rights of the Duke of Normandy, having in their minds the union of their lands on both sides of the Channel under the one ruler, who was to be Duke of Normandy and sovereign of England. The position taken up by the Barons had the immediate effect of drawing the English people to the support of Henry, for the desire of the great majority of the population was that England should be ruled on her own soil by her own King, and not by anyone who must still be considered as a foreign sovereign. The popular movement was successful.

A Blow at Despotism. Henry was crowned King, and he at once set to work to introduce measures which should give his people a better share than they had ever had before in the government of the country. He issued a charter, which Mr. Green says "is important not merely as the direct precedent for the great charter of John, but as the first limitation which had been imposed on the despotism established by the Conquest." The despotism which William Rufus had imposed upon the Church was abolished, and the power which the Conqueror and his son had established, or endeavoured to establish over the Barons, was modified and mitigated so that the Barons were to be liable to certain contributions towards the maintenance of the sovereign's estate, but were no longer to be regarded as mere vassals of the Crown. The rights of the people, although not allowed to extend to what would now be considered as the rights of citizenship, were at least recognised as having some title to consideration, and the principle of citizenship was foreshadowed in the Royal Charter. The Barons' rights and privileges were also greatly modified; their power of absolute mastery over their tenants and dependents, and of extracting unlimited contributions from them, were abolished, and in their place were set out more moderate and definite powers. This charter restored the constitution and the laws initiated by Edward the Confessor, and also established useful and popular reforms in the administration of justice.

The Story of Queen Matilda. Henry also made his position as the ruler of Great Britain more secure by his marriage with Matilda, daughter of Malcolm of Scotland and of Queen Margaret, who was herself descended from one of the earlier Royal families of England. This marriage showed that the King was desirous of proving his resolve that the claims of Scotland, as well as those of England, should be represented in the Royal family. Another reason made this marriage welcome to the English people. The new Queen had been brought up in a nunnery under the control of her aunt, who was its abbess, and this fact was, according to all ecclesiastical rule, an insurmountable obstacle to her becoming the wife of any man, king or subject. Matilda, however, declared that she had been sent into the convent when a child merely to save her from the military troubles overspreading the land; that she had no desire to become a nun; that she had refused again and again to take the veil, and had only given way at last to the orders and the physical compulsion of her aunt.

Anselm, the famous Archbishop of Canterbury, a distinguished philosopher and writer, was then at the head of the English Church. He had been expelled from England by William Rufus because he could not in conscience yield the rights of his Church to the demands of the sovereign. One of Henry's first acts had been to recall the Archbishop to his See. Anselm was appealed to in this struggle between Matilda and the authority of the abbess, and the former was summoned before his Court to plead her cause for herself. Matilda told her story with sincerity and deep emotion. Anselm, whose devotion to the rule of his Church was beyond all question, was devoted also to the cause of justice, and he felt satisfied that the Church never could recognise the arbitrary compulsion of a young girl to become a nun merely because a powerful relative and guardian insisted on the child's submitting to her will. He declared the girl free from the bond of the conventual life, and at liberty to marry the King. The decree was popular among the mass of the English people, and was only disapproved by the Barons and some of the Churchmen.

The Charter of Henry I. The charter of Henry I. was the first step towards the abolition of that merely despotic system which had prevailed during the reign of William the Conqueror, and in the years following, up to the time when Henry introduced his new constitution. The towns increased after that event, and the townships, boroughs, and counties began to be marked out. The King's charter yielded to the towns something approaching to the right of self-government. The heavy Royal tolls imposed on trade were modified or abolished, and the operations of the civil law were deprived of their former despotic character, and made to depend on the principles of constitutional liberty so far as it had then been established, and not on the will of monarch or archbishop or baron. The creation of city corporations had not yet come into actuality, but it was already clearly foreshadowed, and it was becoming quite common in London and other great towns for the burgesses to convene large meetings under the presidency of their aldermen, and to agitate for the reforms needed for the growth of their commerce and the safety of their institutions. The spirit of reform was abroad, and a great improvement, too, was taking place in the relations between Church and people.

Invasion of Normandy. An attempt made by Robert of Normandy to recover his rights to the English throne only led to an invasion of Normandy by Henry in 1105, when Robert was completely defeated, and was kept a prisoner for life. The troubles with Normandy interrupted the development of Henry's auspicious policy for England. These Norman troubles brought also a heavy calamity for the King. Henry's only son, William, whom he had declared to be the successor to the

throne, had with many English nobles, accompanied him on his return from Normandy after an attempt at settlement of the dispute there. The vessel in which William was sailing was far behind the greater part of the Royal fleet. It met with an accident, and Henry's only son was drowned. When the news reached the King he fell to the ground, and lay for some time unconscious; and when he was restored to life is said to have declared that he had come back to the living world never to smile again. The King had a daughter left—Matilda—now a widow, who had been married to Henry V., the Emperor of Germany. Henry declared her heir to his throne, although this seemed strange at the time, and was unwelcome to the feudal nobles, who could not readily accept the idea that a woman should be sovereign of a great monarchical State. Henry's life ended while he was in France, on December 1st, 1135, and there then arose the difficult question of the succession to the throne.

London and the Throne. Quite unexpectedly a claimant appeared who soon made himself very popular. This was Earl Stephen, son of a daughter of the Conqueror, who had married a French nobleman of high estate. Stephen was the nephew of the late King, and had been brought up at the English Court. He was now the nearest male heir, save for his brother, and he had made himself much of a favourite, especially in London, by his pleasant manner, his generosity, and even by his extravagance in spending money. He was born in 1105, and was sent over from Normandy in 1114 to the Court of King Henry.

When Henry settled the crown upon his daughter, Stephen was one of those who accepted the arrangement, and pledged his fealty to the young princess. None the less did Stephen assert his own claim when the news of Henry's death reached him in Normandy He returned to England and presented himself in somewhat melodramatic fashion before the gates of London as claimant to the throne. London responded to his appeal. Stephen had in his train no nobles, and no demonstration was made at any of the towns he passed on his way to the capital; but London settled the question for him readily enough. The constitutional changes made by the late sovereign had given a new and commanding power to its citizens, and had indeed given to all the cities and towns in England an influence they had never before enjoyed. The public opinion of London had long counted for something in the election of a sovereign, but it now seemed to be supreme, and it maintained its supremacy. Neither nobles nor prelates made any display on the side of Stephen, but the citizens and their civic rulers gathered in immense numbers and unanimously declared Stephen King of England, and proclaimed their resolve to maintain their choice with money and men. Stephen tendered his oath that he would devote his life to the peace, the prosperity, and the good government of his dominions. He was crowned King of England in 1135.

The Reign of Stephen. The reign of Stephen was from the first a contrast to its grandiose opening. He had promised peace, prosperity, and order, and nothing came of the promise but war, confusion, and disorder. He began by surrounding himself with bands of mercenary Flemish soldiers, and endeavoured to secure support by showering extravagant favours on some of the great English lords, whom he hoped to buy over. King David of Scotland invaded the North of England as champion of the claims of Matilda. He was defeated in his first battle at Northallerton in Yorkshire, but was able to retain possession of Cumberland. Stephen behaved with great violence towards the prelates who would not support his claims, and he thus had at once the clergy and the feudal barons as his opponents. Matilda—encouraged, no doubt, by the condition into which Stephen had brought himself—came over to England to assert her claims, and England was soon divided into two great rival camps—the supporters of Matilda, who mainly held the West, and the champions of Stephen, who occupied for the most part the East and the metropolis. Stephen met with a severe defeat at Lincoln, and was for a time held prisoner by his enemies, while Matilda made her way to London. There she was not successful, however. Historians tell us that her haughty manners and her too-confident self-assertion must sooner or later have put the people of the metropolis against her. She had to seek refuge in Oxford, and was there besieged by Stephen, who had succeeded in recovering his liberty and in gathering new forces. Matilda escaped from the besieged city, and lived for some years in obscurity, for the most part in Normandy.

Influence of Thomas à Becket. Meanwhile the war in England was becoming a source of greater social distraction and misery. The Barons proved themselves ruthless in their actions against all who had striven against them. The first relief to this condition of bewilderment came from the efforts of Thomas à Becket. His mother was a woman of devout nature and maternal temperament, and his father was an influential man in the civic rule of London. Thomas was educated at the school of Merton, and afterwards went to the University of Paris, where he devoted himself principally to the study of theology. He afterwards entered the Church under the protection of Theobald, Archbishop of Canterbury. Before he received deacon's orders he had fought in the wars like a gallant knight, and had shown himself of surpassing courage and chivalry.

It was mainly through his efforts that the struggle between Stephen and his opponents was brought to a close. Stephen was recognised as King, and he agreed to accept Matilda's son Henry as his heir. Stephen died at Dover in 1154, about a year after this peaceful succession had been secured.

Continued

REPTILES

Extinct Reptiles. Lizards. Chameleons. Poisonous and Non-Poisonous Snakes. Our Native Adder. Sea Serpents. The Cure for a Snake-bite

By Professor J. R. AINSWORTH DAVIS

REPTILES are cold-blooded vertebrates, in which the pure and impure blood poured into the heart are not kept entirely separate, as in birds and mammals. The limbs, when present, do not (in existing forms) raise the body far off the ground, for the elbows and knees are turned outwards; five digits are typically present in either extremity. The body is covered with horny scales, and there may also be an armour of bony plates in the skin. All reptiles develop from hard or tough shelled eggs, which in a few cases are hatched within the body of the mother, but are more usually laid in some warm spot. The young, when they first make their appearance, resemble miniature adults, and have to shift for themselves.

Extinct Reptiles. During the Secondary epoch reptiles were the dominant group of backboned animals on land, while some were adapted to a marine life, and in others the fore-limbs were converted into wings. By the beginning of the Tertiary epoch most of the reptilian orders had become extinct, unable, it would seem, to compete successfully with mammals and birds, their own improved relatives. To these extinct types a few words may be devoted. [For details see GEOLOGY.]

Dinosaurs. The very large order of *Dinosaurs—i.e.,* "terrible reptiles" — included a great variety of forms, of which some were quite small, while others surpassed all existing land animals in dimensions. Some were vegetarians, others actively predaceous; some lived on the dry land, others preferred swamps, fresh waters, or even the zone between tide marks. While most dinosaurs were quadrupeds, some developed powerful hind limbs of disproportionate length, upon which they hopped or walked about. In such cases the adaptation to progression on two legs brought about certain structural resemblances to birds, but these do not indicate close affinities between the two groups.


316. TUATARA

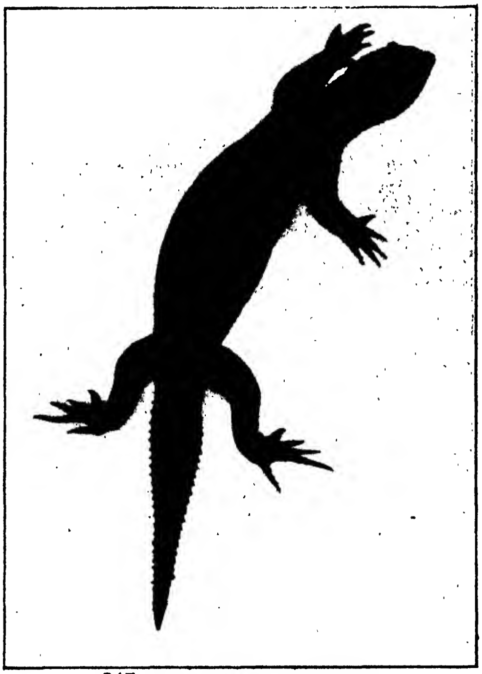
Monsters of the Sea and Air. Among the extinct marine reptiles the *Ichthyosaurs* ("fish lizards") were la ge animals with fish-shaped bodies, paddle-like limbs, and l ng jaws, abundantly furnished with strong conical teeth. The large size of their eyes indicates that they were of nocturnal habit. The *Plesiosaurs* resembled the foregoing in general shape and in the character of their limbs, but the comparatively small head was borne on a long, flexible neck, which probably had much the same use as that of a swan, enabling its possessor to search for food under water without having to dive [see plate facing page 2066]. Even more interesting than the above marine monsters were the extinct *Pterosaurs* ("winged reptiles"), which hunted for their food in the air, and were of the most varied sizes. The skin was drawn out into a flying membrane, disposed very much like that of a bat. But while in the latter all four fingers are greatly elongated into slender supports for this membrane, only the little one was so modified in a pterosaur, and formed a strong jointed rod, by which the outer edge of the wing was strengthened. Hence, as already remarked, no less than three totally distinct kinds of flying organs have been evolved by backboned animals—that is to say, by bats, birds, and pterosaurs respectively.

Although so many groups of reptiles have entirely died out, the class is still abundantly represented among existing backboned animals, and the recent species may be grouped into five orders—*i.e.*, (1) TUATARAS (*Rhynchocephala*), (2) LIZARDS (*Lacertilia*), (3) SNAKES (*Ophidia*), (4) TURTLES AND TORTOISES (*Chelonia*), and (5) CROCODILES (*Crocodilia*).

Tuataras. This group of reptiles was abundantly represented in the earlier part of the Secondary epoch, and corresponds in many ways to the stock from which reptiles in general have taken origin. It included a number of

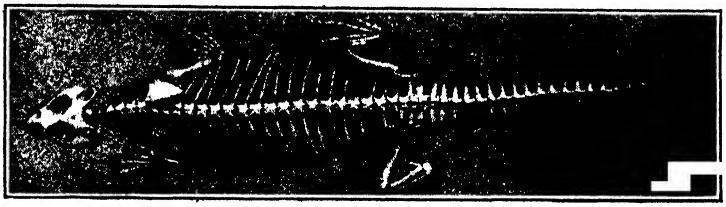
lizard-like forms, presenting many primitive characters, and now almost entirely extinct, being represented only by the Tuatara (*Hatteria*) [316], which lives on some small islands in the Bay of Plenty, New Zealand. It has only been saved from extinction by the fact that New Zealand became isolated at an early date, so that better equipped forms have been to a very large extent kept out of these islands.

Lizards. These may perhaps be described as the most average of existing reptiles, and have a very wide distribution. Four small species are native to Britain, and of these the little sand lizard (*Lacerta agilis*) may often be seen during the summer basking in the sun on banks or scrubby slopes. As long, however, as it remains motionless it is likely to escape observation, for its mottled-brownish skin harmonises with the surroundings, and affords a good example of protective colouration. The little animal is capable of very rapid movement, darting quickly upon its prey, which consists of insects, worms, and other small creatures.



317. SPINE-TAILED LIZARD
Photographed by Prof. B. H. Bentley

Examination of a lizard or its skeleton [317 and 318] enables us to grasp very clearly some of the average characters of reptiles, such as the sprawling limbs and long tail. In many instances the last-named member plays an important part in protecting its owner from an untimely end, for it easily snaps across if suddenly seized by an enemy, and time may thus be afforded for escape. There is a weak place in the backbone which makes this curious procedure possible.



318. SKELETON OF SPINE-TAILED LIZARD

Some of the tropical lizards are of very considerable size, attaining a length of as much as 6 ft., as in the iguanas [319] of America, some of which are esteemed as food. These are among the climbing members of the order, other examples being the geckoes and chameleons of the Old World, both of which are animals of small size. The former have curious pads under their toes, studded with peculiarly shaped hairs, and enabling their owners to scramble up a smooth wall with facility.

A Quick-change Artist. Chameleons are proverbial for the way in which they rapidly change colour if placed among fresh surroundings, so as to harmonise with them. This variable general colouration is protective, because it makes the chameleon invisible to its foes, and also aggressive, as the insect prey of the little lizard are thereby lulled into a sense of false security. The digits are bound together into two groups, and a tongs-like grasping organ of great efficiency is thus constituted. The chameleon is also notable for the relatively enormous distance to which it can suddenly shoot out its sticky club-shaped tongue, for the purpose of seizing insects or other small creatures. Two stages in the process are shown in 320 and 321.

Some lizards have become adapted to make their way through dense vegetation by the acquisition of an eel-shaped form, and the reduction or even the complete loss of the limbs. Our harmless native blindworm (*Anguis fragilis*), often mistaken for a snake, is in reality one of the limbless lizards.

Snakes. These reptiles are the most dominant existing representatives of their class, and are closely related to the lizards. They have undergone the same kind of modification in shape and reduction in limbs just mentioned for certain members of that order. The limbs, in fact, have almost always entirely disappeared, except that in a few instances—*e.g.*, pythons—the hind ones are represented by a pair of insignificant stumps, each of which terminates in a claw.

How Snakes Glide. Upon the underside of most snakes will be found a double series of large, horny shields, to which the ends of the very numerous ribs [326] are attached. By means of appropriate muscles the ribs can be moved so as to bring these shields forward, one after the other, the net result being a rapid gliding motion of progression. One may almost

be permitted to say that a snake walks on the ends of its ribs. At the same time the body undulates from side to side—not up and down—in a wriggling or writhing fashion. The extremely flexible backbone permits of this, but to guard against dislocation the vertebræ are connected by extra locking-joints, which only permit a certain amount of play. It is, however, comparatively easy to break the back of a snake by a sharp blow with a stick or whip, and a knowledge of this fact has saved many lives in India and other countries infested by poisonous serpents. Many such creatures can climb with facility [327].

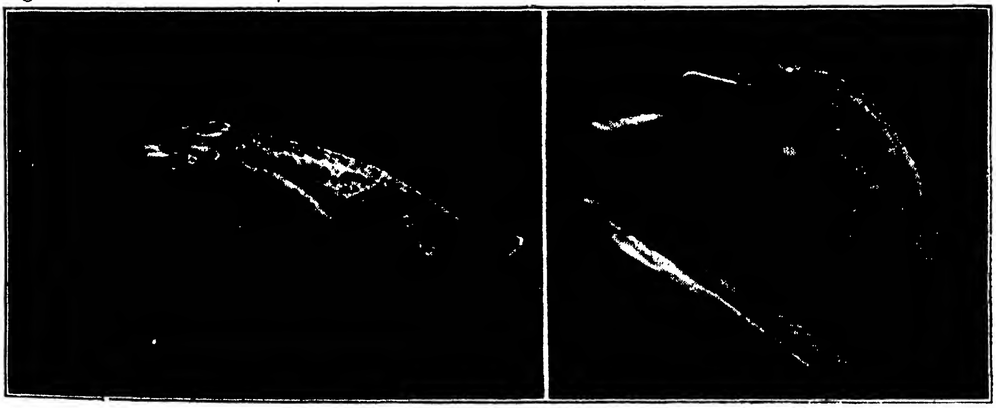
Snakes, like lizards, are very commonly coloured in such a way that they harmonise with their surroundings, this serving the double purpose above described. A good many poisonous forms, on the other hand, advertise their dangerous properties by brilliant hues and striking patterns. Such "warning colouration" is seen, for example, in the coral snakes of tropical America, which are marked with broad red rings, alternating with others of whitish tint, shading into black at the front and back of each ring. These coral snakes serve as models which certain harmless forms unconsciously mimic, thus securing a certain amount of immunity from attack by sailing under false colours.

Photo

319. TUBERCULATED IGUANA

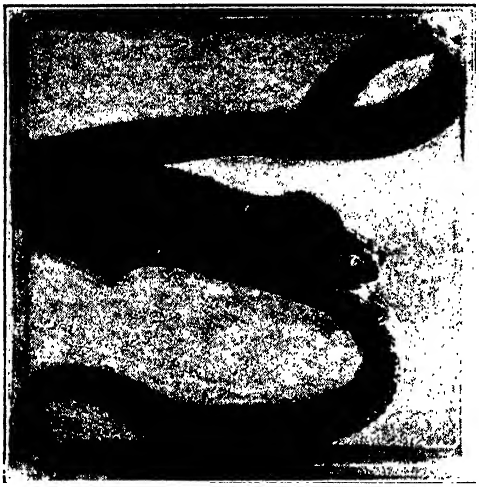
Snakes that Warn. In the American rattlesnakes, at each periodical casting of the skin or slough, a little knob remains at the end of the tail. A series of these loosely united together make up the "rattle," used for the production of warning sounds. The "hissing" of a snake has the same purpose. Venomous snakes also commonly assume a warning attitude, raising the front part of the body from the ground and, in some cases—*e.g.*, cobras—inflating a kind of hood [324], in this particular instance bringing a black, spectacle-shaped mark into prominence. But in these and other animals it must not be supposed that the "warning" is for the benefit of the prey, but may be taken as a hint to aggressive birds and mammals that discretion is the better part of valour. The success of this device is shown by the terror with which all monkeys regard serpents. The production of a toy snake in the monkey-house at the Zoo reduces all its inmates to a state of abject fear. We ourselves share with our "poor relations" this horror of animals which even now are responsible for a great deal of mortality among inhabitants of tropical regions.

Abnormal Feeding Capacity. Snakes are essentially carnivorous, and with the exception of some small, degenerate forms that pursue earthworms underground, are able to swallow animals which are very much larger than themselves; this gluttonous procedure often bringing its own punishment, for the state of lethargy which succeeds the



320–1. THE CHAMELEON AND ITS LONG TONGUE

Photo



322. GRASS-SNAKE AND SWALLOWED RAT
Photographed by Prof. B. H. Bentley

bolting of a meal is, of course, a favourable moment for the onslaught of enemies. Feeding in this way is rendered possible by the extreme power of dilatation the body possesses, which is partly due to the absence of a breast-bone and shoulder-bones. The two bones of the lower jaw are not united, as usual, at their tip, but merely connected by an elastic ligament, which easily stretches. To prevent choking during the tedious process of swallowing, the top of the windpipe is drawn out into a long cone, which temporarily protrudes from the side of the mouth. 322 represents a specimen of our native grass-snake which has swallowed a rat; and the wall of the body has been cut open to show the head of the unfortunate victim.

323. ADDER
Photographed by Prof. B. H. Bentley

Non-Poisonous Forms. A large number of snakes are non-poisonous, and these possess numerous conical backwardly pointing teeth on the edges of the jaws and roof of the mouth which are of no use for chewing, but hold the prey firmly and prevent its escape. Our common native grass-snake (*Tropidonotus natrix*) [322 and 325] is a good example of such forms. It is particularly fond of the neighbourhood of streams, and is an expert swimmer. Its favourite food consists of frogs and fishes. Innocuous snakes also include the largest members of the order—*i.e.*, the boas [327] and pythons of tropical America, which crush comparatively large mammals into a shapeless mass, that is gradually swallowed after lubrication with the abundant saliva.

324. HAMADRYAD STRIKING

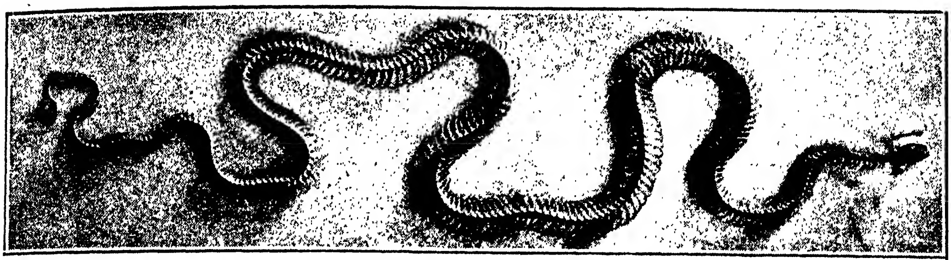
Poisonous Forms. In poisonous serpents some of the glands opening into the mouth secrete a poisonous fluid, which is introduced into the blood of a bitten victim. The largest amount of specialisation is found among the vipers, where the teeth are reduced to a pair

upper jaw, and there are two large poison glands, one on either side of the head, giving it a characteristic resemblance to the ace of spades [323]. The mere shape of the head is, however, no certain test as to the poisonous or innocuous character of any given form.

In a state of rest, when the mouth is shut, the poison-fangs are pressed against the roof of the mouth, with their tips directed backwards. But when the snake opens its mouth and "strikes" [324] the fangs are rotated forward, so that their sharp tips can be brought into action. The poison flows into the upper end of the tooth-canal and, in vipers, enters the wound by a small hole on the side of the tip. Were it at the end a blockage might result. We have, in fact, an anticipation of the device used in the construction of the needles employed with hypodermic syringes.

It may be well to call attention to the external characteristics of our only native poisonous

325. GRASS-SNAKE AND TWO YOUNG
Photographed by Prof. B. H. Bentley



326. SKELETON OF GRASS-SNAKE

snake—*i.e.*, the adder (*Pelias berus*), which is a species of viper [323]. It is particularly common on sandy moorlands. Besides the spade-shaped head, note the dark, broad, zigzag stripe on the upper side of the body.

The Cure for a Snake-bite. A venomous serpent is not poisoned by the absorption of its own poison because its blood contains a complex "defensive proteid" which renders this harmless. It is fortunately possible to make an artificial extract of this substance for given species, which appears to be the only certain cure for the more virulent forms of bites.

It may not be superfluous to remark that the forked tongue of a snake, which can be shot in and out with great rapidity, is not a "sting," but a very delicate organ of touch. It also possibly serves to attract the attention of victims by exerting a sort of hypnotic influence, the so-called "fascination." It is at least certain that small mammals and birds often seem as if they were paralysed on the approach of one of these insidious foes, and make no efforts to escape.

Though naturalists do not know of any marine animal corresponding to the legendary "great sea-serpent," or kraken, a number of aquatic snakes inhabit the Indian Ocean, though these are much too small to be the origin of the myth. Some of them have the tail flattened from side to side for use as a propeller, and all are extremely poisonous.

327. CLIMBING BOA

An Egg-eating Snake. One kind of snake (*Rachiodon*) has discovered the nutritious properties of a diet consisting of birds' eggs, and is possessed of a curious arrangement in connection with this. A tooth-like spine projects into the throat from the under side of the backbone, and this acts as an egg-breaker, the contents of the egg being swallowed while the shell is ejected from the mouth.

The hieroglyphics of the ancient Egyptians constituted a system of picture writing, in which the characters were outlines of various objects. One of these was a snake lurking in the desert sand, and distinguished by the presence of two little horns on the head. In course of time the cumbrous hieroglyphics were simplified, and the drawing of the horned snake became V____ (*i.e.*, the horns and body). By loss of the horizontal stroke our letter V has come into existence.

The Wisdom of the Serpent. In correlation with the presence of a well-developed brain, snakes may be regarded as the most intelligent of reptiles, though the idea of their "wisdom" probably took origin in their stealthy ways, and the curious "fascinating" powers already mentioned. They are among the numerous animals that have been the objects of superstitious worship. They are not difficult to tame, and certain kinds are domesticated in some countries for the purpose of keeping down the numbers of rats and similar pests.

Some snakes incubate their eggs, and show a certain amount of affection for their offspring—though they are far excelled by birds and mammals in this respect.

Continued

NEW KINDS OF ELECTRIC LAMPS

Nernst Lamp, Osmium Lamp, Tantalum Lamp, Mercury Vapour Lamps, Flame Arc Lamps, and Magnetite Lamp

By Professor SILVANUS P. THOMPSON

The Nernst Lamp. The circumstance that metal filaments, such as platinum wires, melt, and that carbon filaments, even when enclosed in a vacuous bulb, disintegrate if heated to a white heat, prevented the earlier kinds of glow lamps from being heated beyond a certain limited temperature, and therefore restricted their efficiency. The best carbon filament glow lamps, unless their life is to be very short, require at least $3\frac{1}{2}$ watts per candle power. To obtain a more efficient lamp some new departure was needed.

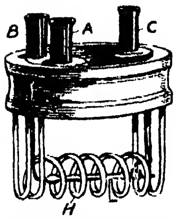
Now, it had long been known that many solid bodies, such as glass and porcelain, which are insulators when cold, become conductors when hot. About the year 1898 it occurred to Professor Nernst, of Göttingen, to examine the properties of filaments of earthy bodies, such as pipe-clay, lime alumina, and zirconia. He found that these substances, if heated red-hot, conducted sufficiently well to admit a current which at once warmed them up to a white heat, and when so glowing they gave out a larger amount of light for a given amount of electric power than carbon filaments did. Thus began the Nernst lamp.

Construction of the Nernst Lamp. To realise such a lamp it is necessary to provide arrangements for the preliminary heating of the filaments. This in turn necessitates some automatic device to switch the current off from the heater when the latter has done its work. Furthermore, since the resistance of the glowing filament goes down the hotter it gets, it is necessary to insert in series with it, to prevent it from taking too much current and destroying itself, an auxiliary or ballasting resistance made of some material which has the opposite property of increasing its resistance as it gets hotter. Such a ballast resistance is constituted by a thin iron wire; but as this would at once be destroyed by oxidation if open to the air, it must be enclosed in a vacuous glass enclosure. The glowing filament, on the contrary, must not be enclosed in a vacuum bulb, as access of air to it is essential. It is, for protection, enclosed in a small globe, but this is not airtight. Figs. **188** to **192** depict the parts of a modern Nernst lamp. The switch device (**192**) is fixed inside the porcelain bayonet-piece D of 190, while the cage K is constructed to hold the ballasting resistance R. The glower G and the heater H are constructed on a separate base, with three sleeves—A, B, and C—which are spaced out unsymmetrically, and which fit into corresponding pegs in the lower part of the cage. The globe, which may be of various shapes, fits on the bottom rim of the cage by a bayonet joint. The whole control of the lamp is effected by the electromagnetic device in the cap shown in **192**. The scheme of connections has been added to this diagram, and it will be seen that when no current flows through the glower the spring is back and makes contact with the fixed stop S; and so current can pass through the heater, but when the glower is hot and current flows, the spring is pulled away from S, and no current passes through the heater.

The Osmium Lamp. As mentioned above, platinum wires are not suitable for the filaments of glow lamps, as they melt too readily. Accordingly, other metals have been sought, which should be less fusible. Dr. Auer von Welsbach proposed to use the very rare metal osmium. As osmium is much too hard to be drawn into a wire, he mixes finely divided osmium with certain organic matter to a paste, which is squeezed through a sapphire die into thin wires. These are first carbonised, and then reheated under a special treatment, which gets rid of the carbon and leaves a thin osmium wire polished like a silver thread. Such a filament when heated by passing electric current through it gives out more light in proportion to radiant heat than a black filament would do. It has, therefore, a higher candle power per watt than the ordinary glow lamp. But the first cost of the lamp is higher, and there has hitherto been some difficulty in producing osmium lamps for voltages over 100. The whiter light of the osmium lamp is in its favour.

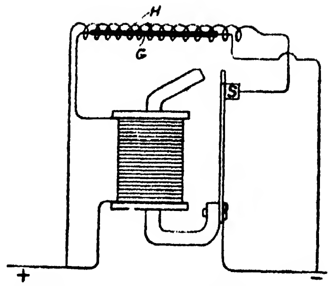
The Tantalum Lamp. Other refractory metals, such as tungsten or wolfram and tantalum, have more recently been proposed, and the tantalum lamp has been put on the market by Messrs. Siemens. The thin silvery-looking tantalum wire is looped up and down inside the lamp upon an internal framework, and presents the appearance shown in **193**. Like other metals tantalum increases its resistance as it grows hot, whereas the resistance of carbon decreases. Hence tantalum and osmium lamps are more steady in their light under a variable voltage than carbon filament lamps. Their average light is at least as great as that of the ordinary glow lamp, and their globes do not blacken as those of carbon glow lamps do as they grow old. Therefore, in spite of their present high cost, they present manifest advantages. As the supply of the metal tantalum is not so limited as that of osmium, tantalum lamps will probably become much cheaper.

Mercury Vapour Lamp. In 1892 Arons devised a lamp in which mercury vapour was rendered brilliantly luminous by the passage of a current through it, and in 1895 this lamp was improved by Lummer, whose lamp is illustrated in Fig. **194**. A glass tube which formed

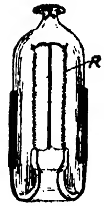


188. HEATER AND GLOWER OF NERNST LAMP

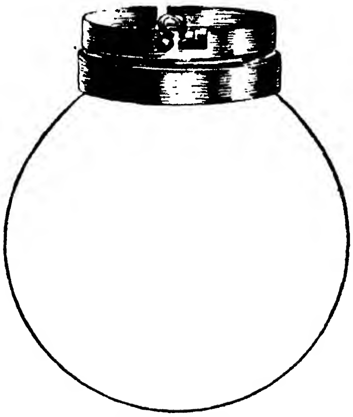
190. OUTSIDE VIEW OF CAGE OF NERNST LAMP



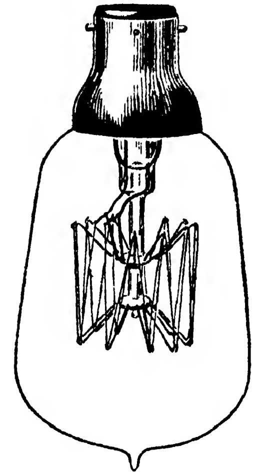
192. CUT-OUT COIL AND SECTION OF NERNST LAMP

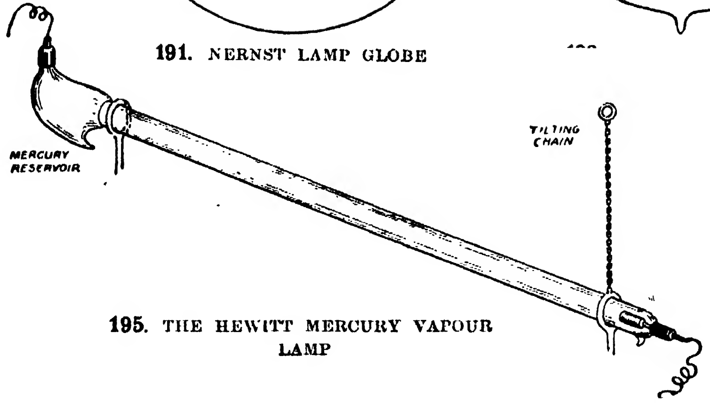


189. BALLASTING RESISTANCE OF NERNST LAMP

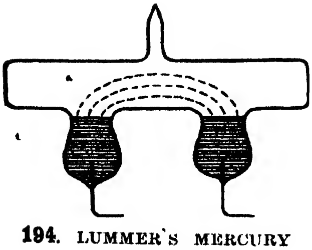


191. NERNST LAMP GLOBE

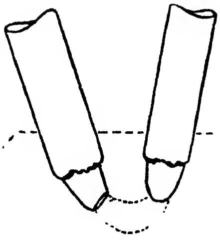




195. THE HEWITT MERCURY VAPOUR LAMP



194. LUMMER'S MERCURY VAPOUR LAMP



196. ARC OF FLAME LAMP

a bridge across two other tubes filled with mercury was exhausted, leaving only mercury vapour, as in the partial vacuum at the top of a barometer. On passing a current through this lamp, a most intensely vivid green light fills the part of the tube where the current passes. Six years later Mr. P. C. Hewitt, of New York, brought out a similar vapour lamp, but with a much longer tube, the luminous column of vapour between the surfaces of the mercury being nearly 20 in. long, or even longer.

With the mercury vapour lamp a difficulty arises in starting the electric discharge. To light the lamp Arons simply shook it, causing the two mercury columns to touch for a moment, and as they parted the light flashed out. In the Hewitt lamp the light is started either by tilting it, or by the momentary application of a higher electromotive force, such as the spark from a small induction coil. When this spark has once passed, the luminous column can be maintained glowing by an ordinary electromotive force, such as 50 to 100 volts. A ballast resistance in series with the lamp is found advisable. Vapour lamps give out very little heat, relative to their light, and in this sense they are very efficient. They are reputed to give 1·7 candles per watt.

A recent form of Hewitt lamp is shown in **195**. It has but one mercury electrode—the positive—for it has been found possible to use as the negative electrode the same substances as are used in the glowers of Nernst lamps.

Recently attempts have been made to mitigate the unpleasant effect of the green rays by use of a cadmium amalgam instead of pure mercury, as this material gives out red rays as well as green ones.

The vapour lamps appear to be admirably adopted for external illumination, and a recent installation of these outside the "Tribune" Buildings, London, is giving every satisfaction.

Flame Arc Lamps. It has long been known that by adding various chemical materials to the carbon rods of the ordinary arc lamp an arc is changed from one of dull blue to one of great luminosity. Every chemist knows that the salts of certain metals will impart colours to the non-luminous bunsen flame, and the same effect is produced in the carbon arc. Among the salts which are chiefly employed for this purpose are calcium fluoride and sodium fluoride; the former of which imparts a brilliant brick-red tint, and the latter a bright yellow. By a combination of the two salts a very pleasing colour is obtained. The light from the flame arc lamp, therefore, comes mostly from the arc itself, and not from the incandescent crater of the positive carbon [see page 2416]. In order to make a satisfactory lamp two things were found necessary. First, the arc had to be drawn out to a greater length, for which purpose a higher voltage was required; and, secondly, in order to maintain a steady arc, the shape shown in **196** had to be adopted. As will be seen, the carbons are tilted to one another at about an angle of 30 degrees, and the arc is maintained in a steady bow by being blown outwards by the action of an electromagnet [see page 1590]. To increase further the useful light from the arc, the carbons protrude through an inverted bowl constructed of some white fire-resisting material, and this reflects all the light in a downward direction. The flame arc gives off a certain amount of poisonous fumes, which renders it unsuitable for interior illumination unless the room is well ventilated. These fumes are also likely to affect the mechanism, so that in many kinds of flame lamp we find that an empty chamber about 4 in. or 6 in. high is provided between the *economiser bowl*, as it is called, in which the arc burns, and the mechanism which regulates the striking of the arc and the feeding of the carbons.

The Magnetite Arc. A type of flame lamp which has not yet been introduced into England is the magnetite arc. A great drawback to the flame lamp just described is that the light is not *white*. It was known, however, that the arc formed between iron rods had this property, and the problem was, how to produce this arc commercially; for if metallic iron electrodes were used the arc would splutter, and molten metal simply drop away from the points of the rods. The solution was found in the use of the mineral magnetite, a stable oxide of iron which is found in nature in large quantities, and is, therefore, cheap. The mineral is ground up, mixed with the oxide of chromium, formed into rods, and either copper-plated or encased in a thin iron tube to render it a better conductor for bringing the current to the arc. In experimenting it was observed that the negative rod only was consumed, so that the positive rod has been replaced by a copper block, which forms a permanent part of the lamp, and is made sufficiently large to conduct the heat away, and so does not gradually melt off.

The arc is arranged vertically, and is opened out to a distance of from ¾ in. to 1 in. by a simple mechanism which resets the negative rod from time to time to the minimum distance arranged for.

Comparison of the Various Sources of Electrical Illumination. For the purpose of comparing the "efficiencies" of the various lamps discussed the following table, giving representative average figures, is added:

Type of Lamp.	Watts per Candle.	Candles per Watt.	Candles per h.p.
Carbon glow lamp	3·3	0·3	220
Nernst lamp	1·5	0·67	500
Osmium lamp	1·5	0·67	500
Tantalum lamp	2·0	0·5	370
Mercury vapour lamp	0·6	1·7	1,250
Ordinary arc lamp	0·67	1·5	1,100
Magnetite lamp ..	0·25	4·0	2,960
Flame arc lamp	0·17	5·8	4,300

Continued

Continued from page 2618

LIVING PROSE WRITERS

Being the First Part of a Short Study in the English Prose of To-day, with Notes on the Leading Writers and Their Characteristics

By J. A. HAMMERTON

THERE is a class of critics who, in their efforts to maintain the pose of "the superior person," affect disdain of all serious criticism of living writers. To them the biography of a living author is an impertinence, and they argue that not until a man has been securely coffined, and the process of disintegration has advanced some considerable way, should any biographer be so bold as to attempt a study of his life and work. They seem to forget that even the Greek drama was employed by the classic writers to comment upon living men, and in modern times great authors have not hesitated to write both in biography and criticism of their contemporaries: Hazlitt, for example, and Sainte-Beuve, above all, a vast proportion of whose criticism was concerned with writers living when he wrote. That is excuse enough for anyone to write in serious strain of authors who are alive, though it is not to be denied that in the making of literature the perspective of time is more important to the forming of a lasting estimate than it is in any of the other arts. In the graphic arts, in the drama, and in music, judgment may be more easily formulated on any contemporary work; but since none but the dry-as-dusts can subsist exclusively on the literature of the past, and contemporary literature must ever be the most widely read, we need make no apology for taking reasonable interest in its creators. For this reason, all studies of the literature that is still in the making, the product of the age we live in, are to be encouraged and to be taken on their merits, without prejudice in their being concerned with an epoch that is still unclosed, or an author who is still alive.

Changing Conditions of English Prose. We have looked into the origins of English prose and have followed, as closely as the limits of our share in the general scheme of this SELF-EDUCATOR would allow, its development through the centuries, excluding from our examination of the nineteenth century writers those who are alive at the time of writing—a plan which may reasonably be thought arbitrary, since it involves the separation of a few authors from those with whom they have more in common than they have with the writers of the generation into which they have survived. But such cases it will be our business to note as we proceed, and, on the whole, no method has commended itself as more simple or direct than that we have chosen to adopt.

The twentieth century prose men carry forward the literary tradition on lines somewhat different from those that were followed by the writers of even the later part of the previous century. We have seen how the newspaper and the magazine diverted the great eighteenth-century talent for letter-writing into public instead of private channels. We have now to notice how the changes in the newspapers and magazines themselves have modified the style and, to a considerable extent, the point of view of those whom we call the writers of to-day. Here and there are a few young writers who haunt the old paths, the "bookish" shades; but in the main the essay has become the "article," and the article, as a rule, has a very definite character foreign to the essay proper. This is due in its turn to the progress of that popular movement inaugurated by the first Reform Act and the rise of the newspaper press. The article is, in other words, the answer to the demand of the people for concise information on subjects which they have had no special opportunity to study.

How the "Article" has Displaced the Essay. With the development of education the exclusive and specialised power of the pen passed from the hands of a "literary" class; the men of letters ceased to be a sort of priesthood. There is no literary "class" to-day, although vastly more men and women make their livelihood by the pen than in any previous age. There is no literary class because so many are potentially literary who are content to remain readers. Then, again, those who write for a livelihood must address themselves to the interpretation and solution of what are called "questions of the day," since it is "journalistic interest" that rules. These "questions," it is true, are often literary in a sense, but every writer who now secures any considerable hold upon the public is compelled to recognise that life is greater than literature. Some thinkers who are generally regarded as "ingenious," but who may have hit upon truth by accident or insight, have forecast a time when the human intellect shall have invented some means of thought communication that will be of more instantaneous effect than the written word. The railway, the penny post, the electric telegraph, the telephone, wireless telegraphy, the "many inventions" of the printing press, may be but landmarks on the way to a time when the "finished" essay or article, the most "graphic" literary art, shall take place with the picture language of the primeval savage and the clay tablets of ancient civilisation, and pass as—

> "Sultán after Sultán with his pomp
> Abode his destined hour, and went his way."

"Human" as against "Literary" Interest. Meanwhile, the demand for the "human," as distinct from the "literary," in letters, has led to a vast increase in the output of fiction. The vogue of the novel has been attended by revolutionary changes in the form of that species of literary work, and has drawn into the service of fiction great numbers of men and women who might, under less competitive conditions, have devoted their gifts and talents to other departments of the literary production. A notable example is found in the case of GEORGE MEREDITH (b. 1828), whose avowedly critical work is represented by one tiny volume, his "Essay on Comedy." Mr. J. M. BARRIE (b. 1860) is another whom the novel, and later, the stage, has claimed, though his miscellaneous writings in literary criticism, not yet, and little likely ever to be, collected into book form, disclose a quite unusual talent for criticism. Then, what the Minotaur of fiction has not claimed the insatiable appetite of the Press has demanded, though here it has been all to the advantage of modern prose literature ; for an immense proportion of modern books, and by no means the least worthy, have first existed as journalism. More and more the daily and weekly newspapers and the monthly magazines are likely to become the mediums of circulating the best that living prose has to afford not only in criticism of life and letters, but in creative fiction also ; the book will be merely the convenient secondary condition of the great body of twentieth century prose, for permanent record and reference. And though it is often lamented that literary standards are low and commercial, the student cannot escape from the conclusion that, apart from the presence in our midst of writers of transcendant ability, and even genius, the general level of literary work is wonderfully high. One further word as to the manner in which we should approach living writers who are also thinkers. They are part of what they themselves have read ; and they must be valued as guides to, and interpreters of, the writers and thinkers of the past, to writers and thinkers who wrote and thought from standpoints other than those of to-day, and consequently require interpretation, in order that their contributions to the sum of human knowledge may not be lost or misplaced in the structure of human progress. But we cannot tarry longer over this fascinating theme. To pass from the general to the particular, we should like the student of English literature who has followed us thus far to take up some book which may be said to mark the parting of the ways.

The Parting of the Ways. By a happy accident, if such a word as "accident" may be used in this connection, a book of the kind we indicate comes to our hand as we write. We refer to the volume of essays entitled "From a College Window," by Mr. ARTHUR CHRISTOPHER BENSON (b. 1862). In these exquisitely written pages the love of books for their own sake finds an expression that is eloquent and deeply impressive. Here is the haunting thought of the genuine man of letters whose affection for the written word is as intimate as Charles Lamb's was. Here also is the joy of the scholar who has settled down in a dream-world of his own with the scholar of an older world, "and heard the silvery bell above him tell out the dear hours that, perhaps, he would have delayed if he could." But—and this touches the point we wish to emphasise—Mr. Benson sees from his college window not only the green and sheltered garden that he loves, with its air of secluded recollection and repose, but "the court, with all its fresh and shifting life, its swift interchanges of study and activity ;" and on yet another side he observes "the street where the infinite pageant of humanity goes to and fro, a tide full of sound and foam, of business and laughter, and of sorrow, too, and sickness, and the funereal pomp of death." The result is, perhaps, a little sad, but there is nothing morbid in this book. The outlook is too clear and manly as well as informed.

The New Note in Prose. Now, this book typifies the new century in a manner that may not at first sight be obvious ; it indicates that the scholar need no longer be a mere creature of the library, living entirely in and for his books, but that he may be equally, or to some extent, a man of the world. This is perhaps the real point of difference between the scholarship of the last century and that of the century in which we are living. The vivifying and humanising influence that comes from participation in the active life of the world is modifying the work of our prose writers so that less and less in the coming years will it "smell of the lamp." In this respect the prose literature of the twentieth is likely to differ more remarkably from that of the nineteenth century than the latter from the prose of the eighteenth. Yet it is no new thing ; it is essentially a return to a condition that has obtained at other times in the history of letters, as we pointed out in our opening study on pages 103 and 104, and it is one of the happiest auguries for the permanent value of the prose work likely to be produced in the present century.

A Great Critic : David Masson. We have spoken of the past. There was no escape from it. Many of the best of our living writers delivered themselves of the best of their work in the past. DAVID MASSON (b. 1822) is an example. Like Dugald Dalgetty, David Masson was a student of Marischal College, but Dugald was a sad pedant, whereas Professor Masson's great erudition is surpassed by the breadth of his sympathies and the volume and versatility of his writings. Famous as a writer who has lent weight and substance to the periodical press, his pen has been employed in the encyclopædias as well as in the reviews. The first editor of "Macmillan's Magazine," he ruled the destinies of that publication from 1859 to 1868. His contributions to our knowledge of the English novelists, and of De Quincey, Chatterton, Carlyle, and Drummond of Hawthornden, have been of the greatest value. He is the one writer since Gifford who has thrown

new light on the life of Ben Jonson. But his greatest work is indubitably his "Life of John Milton, Narrated in Connection with the Political, Ecclesiastical, and Literary History of his Time," a work in five noble volumes which has been described as the most complete biography of any Englishman. His writings on labour and philosophy are almost as important as his studies in poetry, criticism, history, and biography. He began his career as editor of a Scottish provincial newspaper, and in 1852 became Professor of English Literature in University College, London, and in 1865 in Edinburgh University, resigning in 1895, after 30 years of singularly fruitful labour in the advancement of learning. Masson's is certainly one of the great names of the nineteenth century.

Other Leading Critics. GEORGE EDWARD BATEMAN SAINTSBURY (b. 1845), originally assistant-master of Manchester Grammar School, and, like Masson, one-time editor of "Macmillan's Magazine," and his successor at Edinburgh University, is the possessor of a style as polyglot as his reading. He is one of the greatest of living critics, the author of innumerable handbooks on English and French literature, and of valuable biographies of Dryden, Scott, and Matthew Arnold. THEODORE WATTS-DUNTON (b. 1836) abandoned the study of natural history and the law for the fields of fiction and criticism as well as poetry; in criticism he has been one of the forces of the last century. His "Studies of Shakespeare," and "The Renascence of Wonder" are notable productions, but for some of his most remarkable work the student must turn to the pages of the "Examiner," the "Athenæum," the "Encyclopædia Britannica," "Chambers's Encyclopædia," and the leading reviews. He has been for some thirty years the close friend and companion of ALGERNON CHARLES SWINBURNE (b. 1837), whose "Life of Victor Hugo" and other prose studies, especially of Shakespeare, Chapman, and Ben Jonson, are masterly examples of lyrical prose and intuitive criticism. EDWARD DOWDEN (b. 1843) is another student of French and English literature, whose works on Shakespeare and Shelley in particular have become classic. EDMUND GOSSE (b. 1849) has given us Lives of Donne, Gray, Jeremy Taylor, Coventry Patmore, and Sir Thomas Browne, a charming book of "French Profiles," and luminous studies of the seventeenth and eighteenth centuries. With Mr. Gosse must be associated HENRY AUSTIN DOBSON (b. 1840), whose "Eighteenth Century Vignettes" and studies of Steele, Goldsmith, Walpole, Hogarth, Richardson, and Fanny Burney, possess much of the quality of sincerity, scholarship, and feeling which characterise his poems. • STOPFORD AUGUSTUS BROOKE (b. 1832) has made generations of young students his debtor by a consummate "Primer of English Literature." His more bulky works include istory of English Poetry to the Accession of , "English Literature from the Beginning to the Norman Conquest," "English Literature from A.D. 670 to A.D. 1832," a volume of vividly written studies "On Ten Plays of Shakespeare," the "Life and Letters of Frederick William Robertson," and a study of "The Poetry of Robert Browning." For a long period JOHN CHURTON COLLINS (b. 1848), like Professor Saintsbury, was a contributor to the "Saturday Review." He is now Professor of English Literature at Birmingham University, and one of the most solid and severe of critics, whose wide reading and remarkable memory, as well as his acute critical faculty, may be observed to advantage in his famous plea for the study of English Literature at the Universities (1891), his works on Bolingbroke, Voltaire, and Swift, his studies in Shakespeare and the Elizabethans, and in a recent volume, "Studies in Poetry and Criticism." With Dr. Brooke's "Ten Plays of Shakespeare" should be taken the work on "Shakespearean Tragedy," by ANDREW CECIL BRADLEY (b. 1851), till recently Professor of English Poetry at Oxford. A former occupant of this honourable Chair, WILLIAM JOHN COURTHOPE (b. 1842), is rapidly completing an exhaustive "History of English Poetry" in six large volumes. Mr. Courthope, whose aim has been to "use the facts of political and social history as keys to the poet's meaning, and to make poetry clothe with life and character the dry record of external facts," wrote in 1885 a suggestive series of essays on "The Liberal Movement in English Literature." His Oxford lectures, "Life in Poetry: Law in Taste," his admirable monograph on Addison, and his "Life of Pope," written for his standard edition of Pope's works, are productions of high and permanent value. ANDREW LANG (b. 1844) claims consideration as a critic as well as a biographer, historian and anthropologist. He is one of our ripest scholars and unrivalled among men of letters for his versatility. A frequent contributor to "current literature," he has written largely in the daily Press as well as in the reviews and magazines. His more important prose works, apart from translations and anthropological studies, include "The Life, Letters, and Diaries of Sir Stafford Northcote," "Life of Lockhart," "Pickle, the Spy," a work of Jacobite research, and "Sir Walter Scott." Mr. J. W. MACKAIL (b. 1859), who succeeded Mr. Bradley as Professor of Poetry at Oxford, is the author of a little manual on "Latin Literature," which stands quite by itself as an aid to literary self-culture. Mr. WALTER RALEIGH, who succeeded Mr. Bradley as Professor of English Literature at Glasgow, is the author of several works which may be commended for their vigour and the brilliant imagery of their style, as well as for their high educational value. We refer to the "English Voyages of the Sixteenth Century," his studies of Stevenson, Milton, and Wordsworth, a charming book on "Style," and his handbook to "The English Novel." FREDERICK WEDMORE (b. 1844) is an acute critic of letters as well as of art—witness his "Life of Balzac."

Continued

continued from page 2381

WASHING AND DRYING

Washing: Shawls, Blankets, White Clothes. Steeping, Rinsing, Boiling, Blueing, Wringing, and Drying

By ALICE E. MARSHALL

White Shawls. A white shawl should be washed in a warm soap lather, then rinsed in clean water until all soap is removed, folded, mangled, and afterwards well shaken to raise the nap. If dried in the usual way it may get stretched out of shape. To avoid this, a sheet may be spread on the floor of an empty room and the shawl carefully pinned out on to it.

Blankets. New flannels and blankets are often very difficult to wash on account of the amount of sulphur which they contain. If steeped for some time in a soft lather, made with melted soap and ammonia, they can be washed quite easily in the usual way. A breezy day should be chosen for blanket washing, as it is difficult to get them dried quickly. All flannel garments should be ironed with a moderately hot iron when nearly dry. This greatly improves their appearance, the cotton bands, etc., being ironed in the usual way until quite dry.

Washing Coloured Prints and Muslins. The main points to be observed may be summarised as follows:

Wash the clothes in lukewarm water, with melted soap; squeeze them between the hands—do not rub them; rinse them in clean water to which has been added one tablespoonful of salt and one tablespoonful of vinegar, the former to set and the latter to revive the colour; stiffen with boiled starch; fold evenly and mangle; dry quickly—out of the sun; damp with warm water; iron with a moderately hot iron; fold, and air well.

Quick washing and quick drying are absolutely necessary with coloured materials in order to preserve the tints. Some colours "stand" much better than others. Pink and blue fade quickly if very hot water is used, or if the garment is exposed to the rays of the sun. Green has a tendency to "run," and so spoils the appearance and design of the fabric. To check this, one tablespoonful of salt should be added to one gallon of cold water, and the garment be steeped in this for a few minutes preparatory to the washing. In the case of new prints or muslins, this steeping is an advantage in setting the colours and preventing them from "running." Never rub soap on the material, as the alkali in it acts on the colours and causes them to fade. Coloured prints and muslins are not, as a rule, boiled; some prints which are used for making men's shirts are guaranteed to stand this process, but it is better omitted, unless the material has been previously tested and been found to stand boiling without the colour fading in the least degree.

The water in which the prints and muslins are washed must only be lukewarm. Another point to be remembered is that the articles must never be left lying about damp. After being dried, the garments need to be damped again, then folded evenly and mangled before being ironed; this must be done immediately after the mangling. Only a moderately hot iron should be used; a very hot iron causes the colour to fade. Prints and muslins should be ironed on the right side, unless there is a raised pattern, when the article should be ironed on the wrong side only.

White Clothes. The process used in washing white clothes is as follows:

Steep them for at least 12 hours in cold water to loosen the dirt; "poss" well, and wring out of steeping water; wash in clean, warm water, using soap and taking the cleanest things first; rinse in clean, warm water to remove soap and dirty water; boil for about 20 minutes, to improve the colour; rinse in clean, warm water to remove soap; pass through blue water, or, in the case of table linen, etc., add blue to the boiled starch, and pass the linen through this; fold evenly with tapes and buttons inside, and mangle; dry the clothes in the open air, if possible.

The chief points to note in the washing of all white clothes are: the removal of all stains and dirty marks, and perfect cleansing of the material; the keeping of the clothes a good colour; the preservation of the fabric.

Steeping. This is an important point in preserving the material, as the cold water softens and loosens the dirt, making it easier to remove; consequently less rubbing is required, and there is not the same amount of strain on the material as would otherwise be the case.

Washing. After being wrung out of the steeping water, the clothes must, as already stated, be washed in clean, warm water with soap, the cleanest things being taken first. All parts of the clothes should be well looked over, and any dirty parts, such as the neck and wristbands, should have particular attention paid to them.

Soap the parts well, and then rub one piece of the material against the other.

The posser and tub may be used for large articles, such as sheets, which do not require much rubbing. A small nail-brush may be used for collars, cuffs, etc.; it quickly cleans them if they are laid flat on the table, and then soaped well and scrubbed on each side with the brush. All dirty marks must be entirely removed from the clothes before they go into the boiler.

The water should be changed frequently during the washing—in fact, as soon as it becomes dirty. Too much cannot be said of the importance of using plenty of water for both washing and rinsing purposes.

Rinsing. Rinsing, both before and after boiling, is of the greatest importance, as the soap, if left in, turns the clothes a bad colour, and, in conjunction with "blue," forms spots of iron-mould. Tepid water should be used at first for rinsing, in order to get rid of the soap; cold water may be used afterwards.

Boiling. The boiler should not be more than three parts full of water. Enough soap should be added to the water—it should be shredded in—to form a lather, more soap and water being added as the clothes are changed. The order in which the clothes are boiled is as follows:

Table linen; cuffs, collars, etc.; bed and body linen; handkerchiefs; coarse things, such as kitchen towels.

Small things may be put loosely into a bag; this keeps them together, and is also a protection if there is any fear of iron-mould. Twenty minutes is quite long enough to boil the clothes. The water must not be boiling when the clothes are put in, but should be gradually brought to boiling-point. They should be stirred about in the water with two wooden sticks, which are also used when lifting the clothes out of the boiler.

After boiling the clothes will require rinsing again in clean warm water to remove the soap; after this has been done they must be blued, or, if a slight stiffness is desired, be put into boiled starch, to which a little blue has been added.

Blueing. Solid or liquid blue may be used—the former is the better. The blue should be put into a piece of flannel and then be squeezed into the water until the right shade has been obtained. This may be judged by holding some of the blue water in the palm of the hand. It should be of a sky-blue shade; too deep a blue is not desirable. It should be just sufficiently blue to remove the yellow appearance given the clothes by the soap.

The blue must not be allowed to settle at the bottom of the tub, or the clothes will have a streaky appearance. Too many clothes should not be placed at once in either washing, rinsing, or blueing water.

Wringing. Care must be taken when this is done, either by hand or machine, not to strain or wrench the material. The linen should be evenly folded, with the selvedges together—this is the strongest way of the material—all tapes and buttons inside, when wrung by the machine. To wring by hand, gather the material up in the left hand, place one hand above the other, the little fingers together, and wring from right to left the selvedge way of the cloth or garment. A mangle or wringer will accomplish the work much more quickly and easily.

Drying. This should be done in the open air where possible, the early morning air being the best, as it freshens and bleaches the clothes. See that the clothes-lines are firmly fastened at each end, for neglect of this precaution may mean a great deal of trouble if the line comes down, and the clothes have to be washed a second time. They should be hung from the line by the thickest part, and as far as possible in their natural position, a peg being firmly fixed near each end to secure them to the line. Sheets and tablecloths should be hung from the line by folding the two hems one over the other, and fixing a peg a few inches in from each selvedge and one in the middle, to make them quite secure.

Collars and cuffs may be strung together on a tape, a piece of muslin or thin cotton being pegged over them to keep them free from any specks of soot or dust. Clothes must not be hung out in a very strong wind, or they are liable to get torn. Unstarched linen, excepting those articles which have to be cold starched, may be taken down from the line before they are perfectly dry, folded neatly, and placed in the clothes-basket. Those which do not require ironing, such as sheets and towels, may be left lying in the clothes-basket a short time, to acquire an even dampness; they must then be pressed in the mangle to remove the creases.

Sprinkling. As it is impossible to get a good result by ironing clothes which are dry, it is necessary that both starched and unstarched articles which have been dried should be damped again, so that the heat of the iron can take full effect. Table linen, etc., which has been starched with boiled starch, must always be thoroughly dried, and then damped again before ironing, or the iron will stick.

To damp clothes, spread them as flat as possible on a table; hold a basin of lukewarm water in the left hand, and with the right sprinkle the water evenly over every part. Articles which have been starched with boiled starch will not take cold water easily; it causes a dark shade to appear, therefore warm water should be used. After damping, the articles must be evenly folded, passed through the mangle, and placed in a clean cloth in the clothes-basket, ready for ironing. They are ironed much better if allowed to lie a short time in a cool place. Pocket-handkerchiefs need not be dried before ironing; after mangling they should be rolled up tightly in a clean cloth, and ironed damp. This gives them a slight crispness, without being actually stiff.

The body part of a man's shirt should be damped in the same way as other body linen, care being taken that the water does not touch the front or cuffs. If the linen is damped well just above the cuffs and round the edge of the front, it will prevent the starch from entering into the sides and sleeves of the shirt.

Collars, cuffs, etc., must be perfectly dry before being starched with cold starch, or they will not be stiff. All the old starch should be well rubbed out; if any is left in, the linen will have a dull, mottled appearance.

A tablecloth should be stretched into shape whilst damp. Gather the hem up in the hands, and with the assistance of another person pull the cloth gently into shape. Long lace curtains may be straightened in the same way, care being taken not to put too great a strain on the material.

The fringes of towels and tray cloths should be beaten against the edge of a table whilst damp, in order to straighten them.

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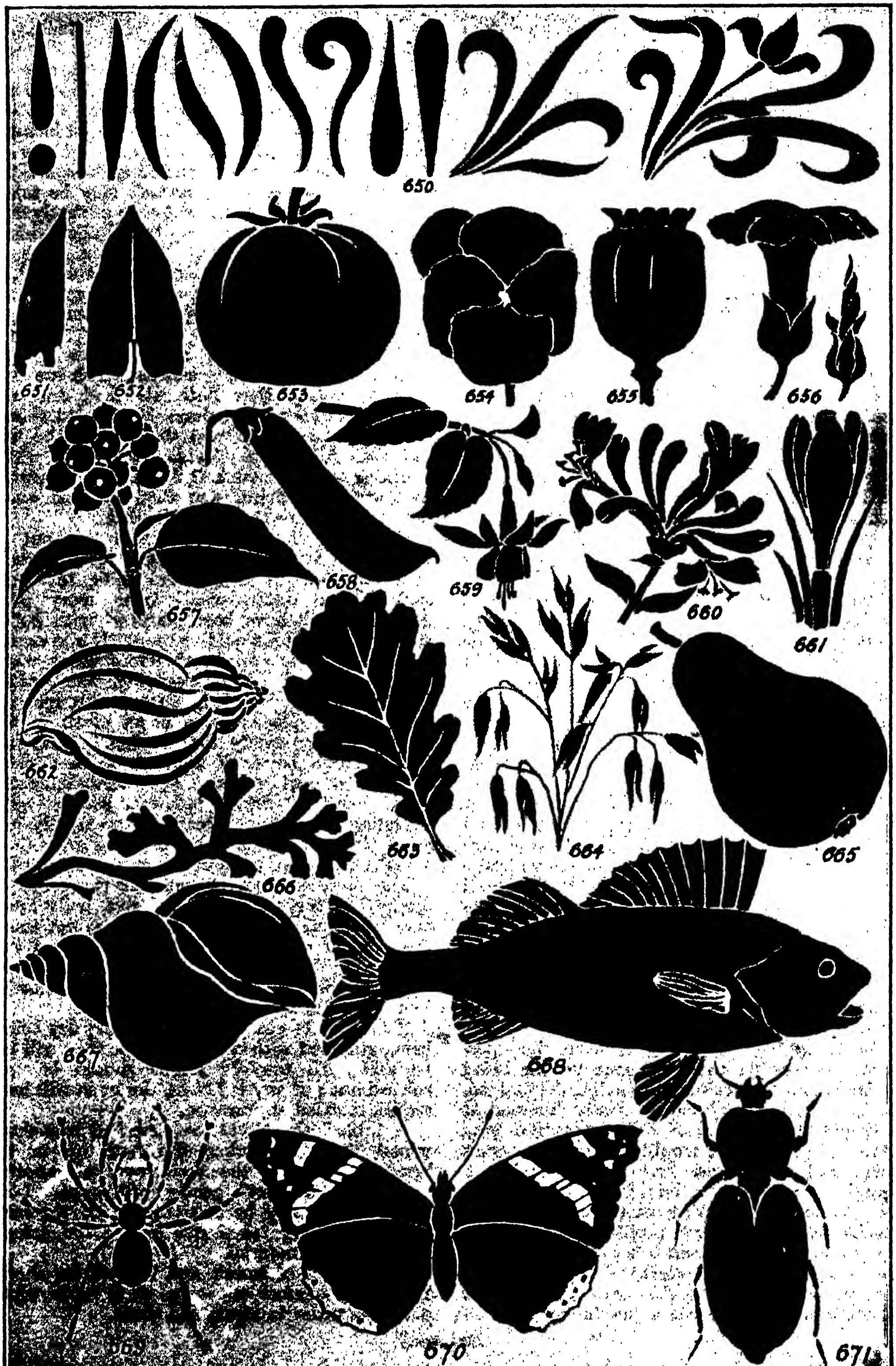


650–671. STUDIES IN BRUSH DRAWING

BRUSH DRAWING

Its Advantages and Characteristic Strokes. Varieties in Tone and Line. Studies of Flowers and Fruit. Greek and Japanese Brushwork

Group 8
DRAWING
19

Continued from page 2569

By WILLIAM R. COPE

Advantages of Brush Drawing. The art of drawing with a brush requires the same training and skill as that which enables one to draw with a pencil or chalk, and should be considered necessary as a part of one's training, instead of merely a separate and distinct manual occupation. Drawings executed in outline with a pointed pencil admit of fine detail, but they have the tendency to cause beginners, unless they have a careful teacher, to think too much, if not entirely, of the edge of the object, and little or nothing of the mass and general proportions; whereas drawing with the brush compels students to train their eyes to see *form or mass*, the general look and even the colour of objects, thus cultivating accurate observation, comparison, reflection and memory, in order that the hand may give a skilful and true expression of what is seen. Truth of drawing must be carefully cultivated, and is not incompatible with an artistic rendering of the object that is studied.

Characteristic Features. The essence of brushwork is that it should be free and not laboured; the strokes should be spontaneous and yet accurate in form, although there may be slight irregularities in individual ones. Rigid mechanical accuracy results in a hard, wooden appearance in the drawing. There is no harm in sometimes using the pencil to sketch in lightly the general form and proportion (but not the details) of a complicated study before beginning the actual brushwork, in order to counteract the tendency towards looseness in drawing with the brush alone.

The flexible point of the brush has its own peculiar capacity, and its own range of treatment. The water-colour landscapes of De Wint are fine examples of broad washes and emphatic brush touches; but Japanese brush drawings [682, see also page 113] show, too, how character and form may be represented by the brush.

Materials and Directions. For paper use O.W.S. "not" surface, but even cartridge will do for many drawings. The brush should be a good sable, and not too small; a No. 7 is a good size to use, with, perhaps, a No. 5 for very small detail when required. The colour may be sepia or Indian ink for studies in monochrome, but any colours may be used. When mixed the colour should be moderately thin, and the brush fully charged with it while the form is being made. Keep a pool of colour on the paper at the lower edge of the wash to ensure clear, bright tones. No attempt should be made to soften or gradate one tone with another, but flat tints should be used, which may be of different colours for the separate parts, say, of a plant with its leaves and flowers; or the tones may be varied for the upper and lower surfaces of the leaf or petal.

Brush Strokes. Command over the brush is absolutely essential for success, and this can only be obtained by constant exercise. A beginner should spend some time in practising preliminary exercises in brush strokes similar to those in the whole row of **650**, in order to learn free movement and the proper handling of the brush. This will be capital training for securing "slick" work, with clean edges, and with pleasant colour in the more difficult studies to be undertaken later.

Studies of Flowers, Fruit, etc. Next procure some natural leaves and flowers, such as those shown in **652** to **664**, and endeavour to represent them in flat washes of colour as indicated, leaving the white paper showing as lines for the edges. **651** indicates how to begin a leaf. Notice the pool of colour at the lower edge as advised. The studies should be gradated in difficulty, so that in time more interesting examples, like those in **665** to **671**, may be chosen for representation. *Always study from Nature.*

Varying Tones. Sometimes exercises may be worked in monochrome in a manner similar to that shown in **672** and **673**, the latter being partly in outline, to suggest the white colour of the flowers. Or different colours in flat washes may be used for the leaves and flowers of a plant. **674** is a study of the laurel, where a light tone has been washed over first, and, when dry, an outline for the edges and veins has been drawn with the brush.

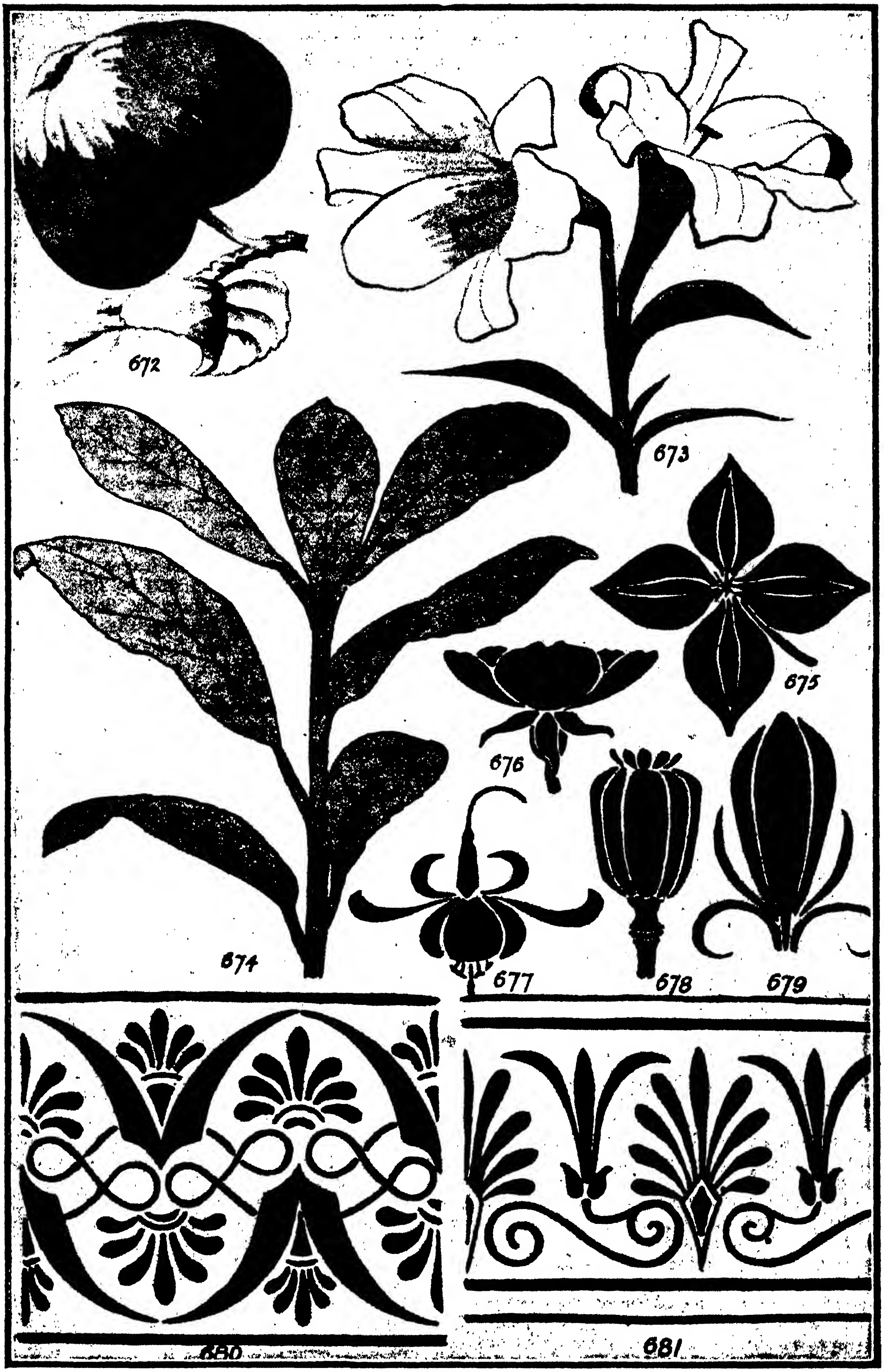
Conventional Representations. When the student has made several careful brush studies of a plant, and so forth, he should be able to give an ideal or conventional rendering of it suitable for design. Thus the brush enables him to improve rapidly his imaginative and inventive faculties. There are generally more regularity, balance, and symmetry in a design than in Nature, as represented in **675** to **679**, which are all conventional.

Greek Brushwork. The Greeks frequently used the brush in decorating their buildings, etc., with designs similar to **680** and **681**.

Japanese Brushwork. The Japanese are world-famed for their brushwork, as exemplified in **682**, which will teach better than hundreds of words what can be accomplished with the brush.

[See over page for illustrations.]

Elements of Drawing concluded



672–681. DIFFERENT STYLES OF BRUSH DRAWING

682. JAPANESE BRUSH DRAWING

Group 3
PSYCHOLOGY
6
Continued from page 2518

EMOTIONS AND INSTINCTS

Instincts the Aspects of Emotions. Physiological Features of Emotions. Contention Regarding the Theory of Emotions. Controlling Emotions. Reasoning Power

By Dr. C. W. SALEEBY

NOW, we must turn to a new department of our subject, and one attended with much difficulty. One of the earliest of the great books dealing with the emotions is that of Professor Bain, "The Emotions and the Will"; and the title is worth remembering if only because it suggests the importance of emotions in relation to the will, or, in other words, in relation to action. Best of all is it to note the meaning of the word and to observe, in general, that motion is associated with emotion. But since Professor Bain's day a new light has been thrown upon this subject by the theory of evolution. We are able to turn to the lower animals and to study in them, not of course their emotions directly, since we can never directly communicate with another consciousness, but those acts which are associated with their emotions. In other words, we begin by considering the emotions not as we have experienced them within ourselves, not by the older method of introspection, but by the newer method of objective study.

Emotions and Instincts are One. The great discovery which we have to recognise is that what we call *instincts* are the obvious aspects of emotions. Not only do the two go together, but they are essentially one. Now, what is an instinct, looked at objectively? According to Spencer, it is a "compound reflex action." More than this, it is a compound reflex action which is not the product of individual experience, but, in the animal or in the baby, has the same results in furthering the life of the creature as if it had had individual experience. In other words, the nervous system is so constructed—by inheritance and not as a result of experience—that, in given circumstances, even if they be entirely new in the personal experience, the creature acts in a fashion which subserves either his own life or that of his race.

It is here impossible to go into the subtle question of the origin of instincts. We must simply accept the fact that each new creature is able to perform instinctive or compound reflex actions which have a definite value for himself or for his species, even though he has no individual experience of his own to serve in directing those actions. We, also, have instincts—the instinct to avoid a motor-car or dangerous heights, the love instinct, the instinct for possession of "portable property," and many more. But when we examine our own instincts we find that these experiences of ours are accompanied by a particular state of mind, and this we call an *emotion*. We instinctively avoid the dangerous motor-car; at certain times we instinctively seek the company of others. But these experiences and actions are accompanied by emotions. As each of us reasons from himself to his fellow-men, to savages, to children, and to the lower animals, the conclusion must be reached that, at bottom, *emotions are the psychical accompaniments of those physiological or physical actions which we call instinctive.*

Emotional Accompaniment of Instinctive Acts. In man the importance of the emotional accompaniment has come very greatly to exceed the importance of the instinctive act itself, and for the reason that, in virtue of our intelligence or reason, we are now constantly in the habit of inhibiting these instinctive or compound reflex actions by means of the activity of higher centres, in the fashion already explained and illustrated. But though the instinctive action may be prohibited or inhibited, its emotional accompaniment remains, and plays a very large part in our experience.

For many decades psychology has treated of the instincts of animals and the emotions of men as if these were two independent subjects; and it is a very great advance indeed for us to recognise, as all psychologists now do, that these are really opposite aspects of one and the same subject. In our own case we feel the emotions and lay the greatest stress upon them, the instinctive actions being often inhibited altogether, and the more so in thoughtful people, such as writers and readers of psychology. But when studying the lower animals we cannot feel their emotions, though we see the instinctive actions which they accompany; and so, in this case, it is upon these last that the greatest stress has been laid.

Emotions and Organic Sensations. Now, in order to understand the modern conception of the emotions, it is necessary to point out that, alike in the case of the lower animals and of ourselves, instinctive actions, such, for instance, as that of flight from danger, are accompanied by a number of changes—actions of sorts—within the body itself. The heart is affected and the size of the bloodvessels, the breathing and the skin. In the case of flight, it can be shown that all the many changes which occur in the body and which we say are caused by fear, tend, if they be not excessive, to serve the act of flight and make it more effective. In order to fly or run very quickly the breathing and the action of the heart must be accelerated; large quantities of blood must pour rapidly through the organs which are being used—*viz.*, the muscles of the limbs. Blood is consequently withdrawn in large measure from the skin and the glands. Hence, the skin becomes cold and pale, the mouth and throat become dry, and if, at such a moment,

it is sought by food to excite the flow of saliva, it is found that the glands in question are unable to produce their secretion. It might easily be shown by many illustrations in the case of other emotions how other series of modifications are produced, which tend to effect the performance of the corresponding instinctive action. Furthermore, common to all emotions is a series of bodily changes which, unless grossly exaggerated, tend to make the body more effective in performing the instinctive action which will serve either its own end or, in the case of certain emotions, the end of the species.

What is an Emotion? Upon these things all psychologists are now agreed, and there remains the one very interesting question: What exactly constitutes the emotion? Now, in seeking to answer this question the first thing that strikes us is that, in addition to the sensation of the external object in question, and in addition to the externally directed action which is thus produced—an instinctive or compound reflex action—there are all these internal changes within the body. Now, since we have already noted the existence of the so-called internal or organic sensations, may it not be that what we call an emotion is simply our appreciation of certain changes in our internal or organic sensations, these changes being induced by the various internal bodily changes which, as we have seen, accompany instinctive action. We have already noted that feeling-tone is very prominent in connection with these primitive and deeply rooted sensations; and, of course, we know that feeling-tone is a very prominent fact of emotion, as we hint when we speak of an agony of fear or an ecstasy of joy.

A Twenty Years' Controversy. The theory of the emotions which has been hinted at was propounded more than 20 years ago by Professor William James, the illustrious psychologist of Harvard University. A similar theory was also advanced by the German student Lange, and so this is sometimes known as the James-Lange theory of emotion. For 20 years it has been the subject of never-ceasing controversy—a fact which in itself is quite sufficient to suggest that the theory is well worthy of our study. At this date, indeed, it may confidently be said that this brilliant theory is now well on the way towards establishing itself. According to this theory, then, an emotion consists in a perception, as a united whole, of the sum of organic sensations due to the internal changes which are reflexly produced in us by the object or cause of our emotion. It is well worth noting that the theory has been misrepresented as if it were asserted that "an emotion is but a sum of organic sensations."* It is more than that; it is the union of all these organic sensations into one perception or percept.

Do We Cry Because We are Sorry? Let us quote from Professor James: "The feeling in the coarser emotions results from the bodily expression. Our natural way of thinking about these emotions is that the mental perception of some fact excites the mental affection called the emotion, and that this latter state of mind gives rise to the bodily expression. My theory, on the contrary, is that *the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur IS the emotion*. Commonsense says, we lose our fortune, are sorry, and weep; we meet a bear, are frightened, and run; we are insulted by a rival, are angry, and strike. The hypothesis here to be defended says that this order of sequence is incorrect, that the one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble because we are sorry, angry, or fearful, as the case may be. Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colourless, destitute of emotional warmth. We might then see the bear and judge it best to run, receive the insult and deem it right to strike, but we should not actually *feel* afraid or angry."

Support of the Theory. Professor James proceeds to point out that, notwithstanding apparent objections to this theory, yet "particular perceptions certainly do produce widespread bodily effects by a sort of immediate physical influence, antecedent to the arousal of an emotion or emotional idea." He quotes instances from listening to poetry and hearing music, and goes on to say: "If we abruptly see a dark, moving form in the woods, our heart stops beating, and we catch our breath instantly, and before any articulate idea of danger can arise. If our friend goes near to the edge of a precipice we get the well-known feeling of 'all-overishness,' and we shrink back, although we positively know him to be safe, and have no distinctive imagination of his fall." The present writer knows a lady and her brother, neither of whom can permit a friend to lean over a barrier at any height so as to look down. Even where there is absolutely no danger whatever, and where there is absolutely no fear, the mere sight of what in other circumstances might constitute danger directly produces a painful emotion, thus confirming Professor James's theory and showing that common-sense is wrong when it says that we tremble because we are afraid.

Medical Proof. Professor James goes on to adduce much further evidence in favour of his theory. He shows that every one of the bodily changes, whatsoever it be, is *felt*, acutely or obscurely, the moment it occurs. This may seem an excessive statement, yet it will be found to be true by any one who cares very carefully to observe his own experiences. Another powerful argument is furnished, to quote Professor James, "by those pathological cases in which the emotion is objectless . . . In every asylum we find examples of absolutely unmotived apathy which persists in spite of the best of outward reasons why it should give way." Remarkable proof of Professor James's theory is furnished

to the medical mind by the symptoms of the well-known disease which is called *angina pectoris*. In this disease there occur severe attacks, which are due to some embarrassment of the heart, and which produce the following picture: "Thus, to take one special instance, if inability to draw deep breath, fluttering of the heart, and that peculiar epigastric change felt as precordial anxiety [popularly, 'that sinking feeling'] with an irresistible tendency to take a somewhat crouching attitude and to sit still and with, perhaps, other visceral processes not now known, all spontaneously occur together in a certain person, his feeling of their combination *is* the emotion of dread; and he is the victim of what is known as *morbid fear* . . . the emotion here is nothing but the feeling of a bodily state, and it has a purely bodily cause."

A Cure for Passion. We may quote some practical illustrations which show the truth of this theory. "Everyone knows how panic is increased by flight, and how the giving way to the symptoms of grief or anger increases those passions themselves. Each fit of sobbing makes the sorrow more acute, and calls forth another fit stronger still, until at last repose only ensues with lassitude and with the apparent exhaustion of the machinery. In rage, it is notorious how we work ourselves up to a climax by repeated outbreaks of expression. Refuse to express a passion and it dies. Count ten before venting your anger, and its occasion seems ridiculous. Whistling to keep up courage is no mere figure of speech. On the other hand, sit all day in a moping posture, sigh, and reply to everything with a dismal voice, and your melancholy lingers. There is no more valuable precept in moral education than this, as all who have experienced know: if we wish to conquer undesirable emotional tendencies in ourselves, we must assiduously, and, in the first instance, cold-bloodedly, go through the *outward movements* of those contrary dispositions which we prefer to cultivate. The reward of persistency will infallibly come, in the fading out of the sullenness or depression, and the advent of real cheerfulness and kindliness in their stead."

These quotations have been carefully chosen, and we would direct attention to their authoritative character.

Emotion in Animals. Various experiments have been made in order to test the truth of Professor James's theory. It was found by Professor Sherrington, of Liverpool, that when the nervous system of a dog was so interfered with that its organic sensations could not reach its brain, it still exhibited the symptoms of emotion. Hence, it has been concluded by opponents of the theory that these experiments "show conclusively that normal emotional states *are* possible, along with complete visceral anæsthesia." But this assumes that because such dogs display the instinctive response, therefore they experience the emotion. Doubtless, however, the professor's theory is true, and they do not experience the emotion; the experiments are absolutely consistent with the theory, and are strictly parallel to the cases which Professor James quotes where loss of organic sensation in the insane was accompanied by absence of emotion. In these cases the bodily expression of the *emotions* so-called, or rather the bodily changes which emotions accompany, *are produced, though the emotions themselves are not felt.*

For further consideration of this great theory the reader must be referred to its author.

The Power to Reason. The greatest of all poets has expressed, in a famous passage, the characters which most distinguish the human race. Thus says Hamlet, "What a piece of work is a man! How noble in reason! How infinite in faculties! In form and moving how express and admirable! In action how like an angel! In apprehension how like a god! The beauty of the world! The paragon of animals!" Now, it is a very common view, met more especially amongst young persons of both sexes and amongst women generally, that man's reason is the noblest of his attributes. This, however, neither the psychologist nor the moralist can admit. The moral nature of man is nobler than his intellectual nature. Nevertheless, without his reason he is incompletely human, and therefore the subject demands close study.

The "Faculty" Psychology. Not many years ago, students of mind had the trick of dividing the mind into a sort of series of watertight compartments. They spoke of the faculty of reason, the moral faculty, and so on and so on: while nowadays we rather contemptuously talk of their conception of the subject as "the faculty psychology." It was based upon notions which are akin to those of the old phrenology. Just as Gall and Spurzheim divided the brain into a number of different portions, each with its own faculty, so the older psychology divided the mind. But now, though there is no objection to the occasional use of the word faculty for convenience, we must never permit ourselves half-consciously to accept the assumptions which its former use expressed. The processes and characters of the mind cannot be divided into faculties. Directly we come to analyse any one of them we find that it is inexplicably mixed up with and compounded of all the others. We must beware of retaining the old erroneous idea, while rejecting the old terminology. Having ceased to talk of the reasoning faculty, the volitional faculty, and the moral faculty, we must not speak of reason, will, and moral feeling as if these were truly independent entities. That is not the way in which the mind is constructed.

Continued

MOULDING BOXES

Different Forms of Boxes: their Construction and Use. Brass-moulders' Boxes. Casting in Alloys. Calculating the Weights of Castings

Group 12
MECHANICAL ENGINEERING
19
WORKSHOP PRACTICE
continued from page 2547

By JOSEPH G. HORNER

MOULDS cannot be made without boxes or flasks of some kind. There is only one to this—those moulds made in open it these are a mere trifle in comparison with the work done in boxes. They require little skill, and are reserved chiefly for the making of the moulding boxes themselves and the roughest class of foundry tools, as core plates, core rings, grids, lifters, and such like. A moulding box is essentially an open-frame box for enclosing and confining the mould. It may be made of stout wood, as is sometimes the case both in iron and brass foundries, especially in America, but it is generally made of iron. Boxes are subject to great stresses, due to the hard ramming of the sand within, the pressure of molten metal, and the twisting strains due to the handling and turning over when loaded with sand and castings. For this reason they are made stout and strong.

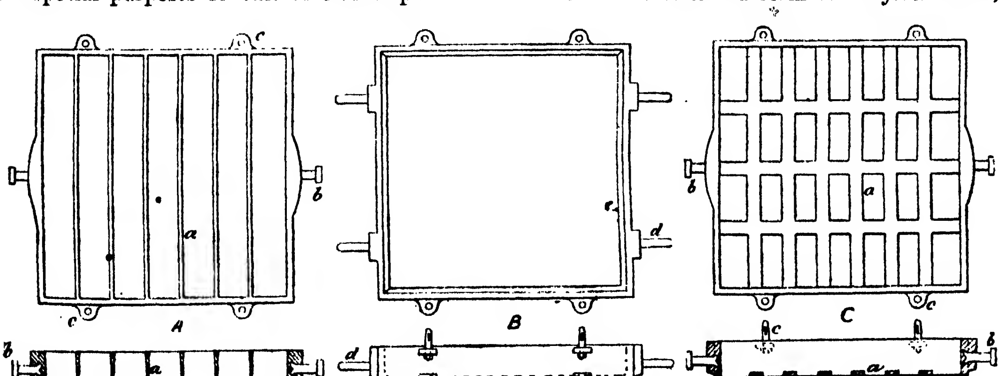
Then, further, since the carrying of a large mass of sand by its simple friction within the sides of the box would be impossible in those of large areas, cross-bars or stays are made to reach across from side to side at intervals of a few inches. Also, since the adhesion of the sand is much assisted by rough surfaces, the boxes are purposely cast very rough, and, in fact, their inner faces and the surfaces of the bars are sometimes artificially roughened over. Then provision has to be made for uniting the box parts of a set to one another, and also for turning them over. Other provisions are made in some cases, such as flanges for back plates, holes for core-bars, for core-vents, etc.

Forms of Boxes. The forms of boxes vary in almost every conceivable way. They are mostly rectangular, being both square and oblong. But many are circular, some polygonal, and a few for special purposes of various odd shapes.

There are several conditions by which the forms of boxes used for different purposes are governed. Thus, when patterns are moulded by bedding-in, by turning over, and in middle parts, corresponding differences in the forms and fittings of the boxes are necessary. When a pattern is moulded by *bedding-in*, a top box alone is used [**108**, A]. That is, the whole or a portion of the pattern will be rammed in the sand that forms the floor of the foundry, and its top face only, with such portions as may happen to project from that upper face, will be formed in the box.

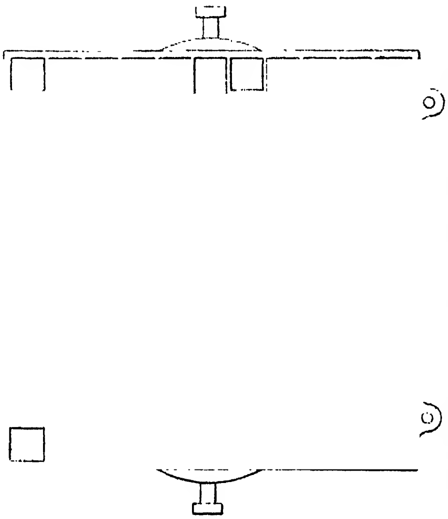
In the figure, *a* represents the stays or bars which serve to retain the sand securely from the chance of tumbling down, assisted by "lifters," which are suspended from their top edges [**102**, page 2541]. The bottom edges of the bars are kept back a little way (¾ or 1 in.) from the joint face to give room for a stratum of sand, and the edges are chamfered to allow the ramming which takes place through the top to have full effect under the bars, which it would not do if they were square.

Boxes for Turning Over Work. In all moulds that are made by the process of *turning over*, the boxes consist of two or more parts. Boxes that are used in turned-over work are necessarily divided, and the number of their joints corresponds usually, though not invariably, with the number of joints by which the mould is divided. When a box is in two sections only, those two may be perfectly symmetrical and alike, or their bars may be of different forms, and variously arranged. When a box is divided into more than two portions the middle part or parts always differs from the top or bottom, being usually destitute of stays. In **108**, while A is a top, B is a middle, and C a bottom box, or drag, B is destitute of bars, C has flat ones. The section of the standard form of unsymmetrical,



108. STANDARD BOX TYPES FOR TURNING OVER IN

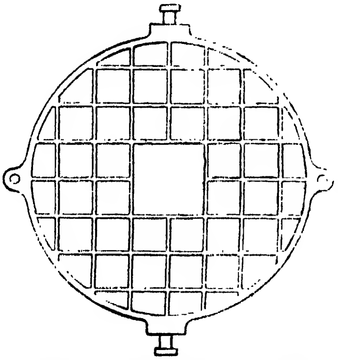
two-parted box is when A is placed on C. In the three-parted, B comes between A and C. The shape in plan may be square, as shown, oblong, circular, or any other special form. Observe the difference in the shape of the bars in A and C. Since the part C rests upon the floor, there is no risk of the sand falling down, as there is in the top A, where the sand is liable to fall into the mould. The bars in C are, therefore, simply flat, and they keep the body of the sand in the box distinct from that on the floor. But the bars in A serve to support the mass of sand above the mould. B has no bars, because they would be in the way, the centre portion being occupied with the mould. But as it is necessary to give some support to the sand surrounding the pattern there, in middles for jobbing work internal fillets, *e*, are cast around the inside. Upon these, rectangular rods of wrought or of cast iron are laid, and lifters hung or placed to afford support to the sand. In middles used for standard work, bars are often cast across those sections where they would be out of the way of the pattern.



109. STANDARD SQUARE BOX

A and C are furnished with the usual swivels *b*. But in middles, B, and other boxes of small dimensions, say below 2 ft. 6 in., square handles, *d*, are frequently cast, the boxes being lifted off, and, if necessary, turned over by hand.

Figs. 109 and 110 illustrate two top box parts in plan, square, and round respectively, and show the arrangements of bars usual in boxes of large dimensions. Fig. 110 is for wheels and pulleys, and the central opening is left for casting the boss through.



110. STANDARD ROUND BOX

Some Special Forms Boxes specially for small work are shown in subsequent illustrations. Fig. 111 is a small box destitute of bars, and having only internal fillets to retain the sand. The drawing also shows the pouring of a handwheel. Fig. 112 is a box used largely by brass-founders. In these the sand is retained without ribs by the angularly recessed sides, assisted by the internal ribbings, *a*, cast in. This type of box is tilted at a slight angle from the perpendicular, and poured through the holes *b*.

The ancient type of brass-moulder's box, retained still in most shops, is shown in 113. This also is poured on end through the holes seen. The box parts are held together by the wooden screw clamps and back boards, necessary to retain the sand during pouring. Very often the boxes themselves are made of wood and hinged, closing like the covers of a book.

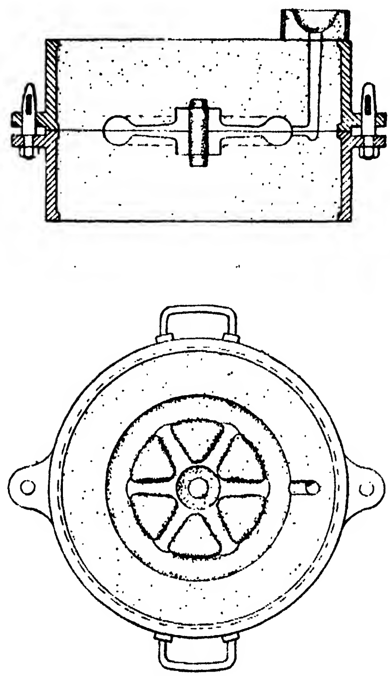
Fig. 114 illustrates one of the later developments in boxes, the "snap" flask. It is hinged at one corner, and clamped at the corner opposite with a catch, so that after the mould is rammed the box is opened as indicated by the dotted outline, leaving the mould on one of the bottom boards. The great economy of this is that moulding boxes are not used to enclose the mould after its removal for casting. A ring of iron is rammed in the mould, and sustains it when out of the box. In this way one box will serve to produce dozens of moulds ready for casting. This method is, of course, suitable only for small moulds not exceeding about 12 or 15 in. across, but within these limits it is largely employed.

Castings in Various Alloys. The differences between making moulds for iron, steel, brass, and aluminium are considerable, and of much practical importance.

The facts of crystallisation and shrinkage lie at the bottom of these. Precautions that are, to say the least, judicious in iron castings, become more imperative in steel because of its larger amount of shrinkage. The first points to observe are uniformity of sections in adjacent masses, the avoidance of keen angles, and, after that, regular rates of cooling down. The crystalline formation of cast iron is not affected to the same extent by the internal stresses set up by disproportioned adjacent masses as that of steel is. If an iron casting be pulled and stressed in this way the chances are that it will break, being torn asunder by these stresses in cooling. But steel is so strong that though it may also fracture, it is more likely to crack simply, or to become distorted only, the parts subject to tension stretching and yielding.

This is always observable in castings in which massive and slight portions lie adjacent. The heavy masses shrink apparently to more than the normal coefficient of shrinkage, and the lighter masses less, with the results just mentioned.

Lessening Evils Due to Shrinkage. The effects of shrinkages on steel castings are minimised in various ways. A common method when a casting is shrinking hard against a portion of mould, or of a core, is to loosen or remove it as soon as possible after the metal has set. Akin to this is the uncovering of heavy portions of moulds, especially of thick bosses, to hasten the dissipation of heat therefrom, leaving thinner parts adjacent still covered. Another is to strengthen weak sections either by thickening the metal, or by casting large radii or brackets in. The latter are generally preferred because they do not produce "draws," as a thickening of the metal is liable to do. The exigencies of steel shrinkage are responsible for the addition of large numbers of these brackets, which are inserted at the judgment of the moulder or the foreman, additions which are practically non-existent in iron-founding.



111. SMALL ROUND BOX WITHOUT BARS

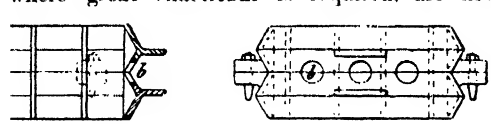
As, therefore, the shape of a casting cannot always be altered at pleasure in a radical fashion, we see that the following courses are open.

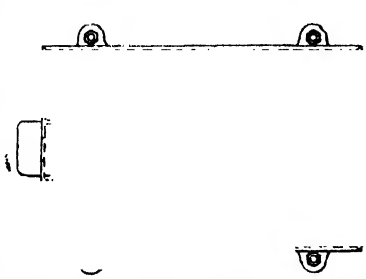
Lessen the thickness of the bosses, increase the radii of the fillets everywhere, and increase the size and number of the brackets in the angles. When necessary, cast a number of brackets similar to those on the flanges of tank-plates, simply to reinforce the casting against strains liable to crack it. Then there must never be any abrupt angles or corners where the sections meet, but large radii or fillets, or strengthening brackets, *must* be inserted. Fillets often meet the case, but they should be sufficiently large to affect the direction of the lines of crystals. Even though it should happen that finished piece of work must have a keen angle, it must be cast with a radius, to be turned or planed out subsequently. To this rule there is no exception in steel castings.

Heavy brass castings are liable to shrink and produce draws, and hollow and open unsound places. Such work is poured in much the same way as iron—that is, it is fed with fresh hot metal to supply the settling down due to shrinkage. This is done either through the runner, or, better, through a riser. The metal must be poured dull, and quickly. But brass castings are not liable to fracture as those of iron are.

The researches of the "Alloys Committee" bear out and help to explain facts that have always been known in the foundry in regard to the heat at which metal is poured. "Hot metal" and "cold metal" are in regular request. In casting aluminium, the difference between pouring at a low red and at a bright red heat effect most radical differences in the physical properties of the castings. Aluminium is an exception to the rule which ironfounders have to regard strictly—that metal must be thoroughly melted and brought into a perfectly fluid state, even though it is subsequently poured "dead," or "cold."

Weights of Castings. To be able to estimate the weights of castings correctly is of value to a moulder. To have insufficient metal in the ladle is as inexcusable an error as having a great deal too much, to be poured, perhaps, upon the floor. But as there is little time for very accurate calculation involving a large number of figures, it is well to acquire the practice of striking rapid averages, and using a few common and readily remembered figures and multipliers. Exact methods of calculation, which in cases where great exactitude is required, are not





112. BOX USED BY BRASS-MOULDERS

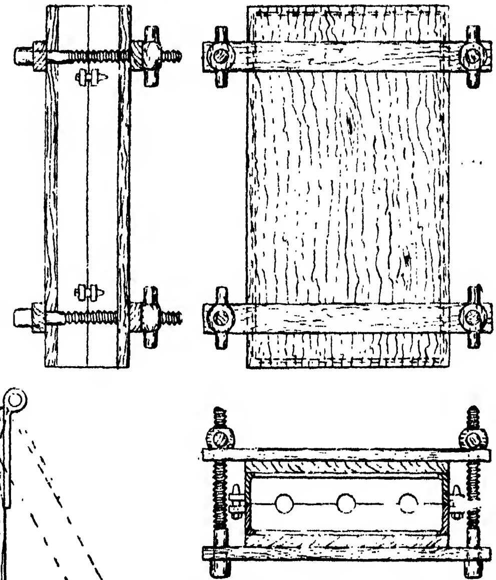
usually necessary when the object is only to learn the approximate quantity of metal to melt, or tap out for pouring. Some of the rules are associated together as follows:

The basis of all calculation is to estimate first the quantity of cubic inches of metal in a casting. This, of course, involves the application of the common rules of mensuration to the patterns. This need not be done exactly by textbook rules. There are many short cuts for getting at these in an approximate fashion. Cylindrical work is reckoned out in several ways. An annular ring of metal is readily reduced

to a superficial plate by obtaining the circumference and multiplying that by the length. If the metal be thin, and the diameter large, no very appreciable difference will result from taking either internal or external diameter from which to deduce the circumference. But in proportion as the diameter diminishes and the metal thickens will the discrepancy increase. Hence, it is necessary in order to obtain correct results that the *average* diameter be taken. Then that may be multiplied by $3\frac{1}{7}$, or by 3·14159 for circumference, or a proportion sum be made thus:

7 : 22 :: diam. : circum.

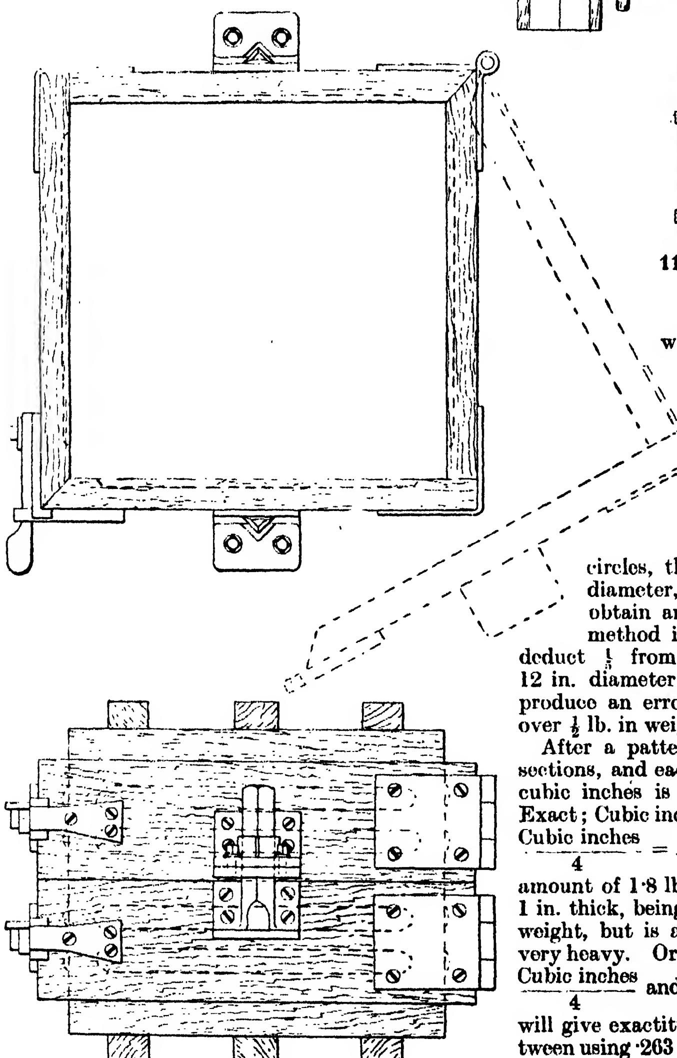
Multiplying the circumference by the length and the result by the thickness gives the solid contents. Having a conical cylinder, the average diameters at each end can be taken, the circumferences deduced, these multiplied by the thicknesses, the two products added together, and divided by 2 for the average result, and this last multiplied by the length for the total solidity. Or the average diameter and thickness can be taken at once and multiplied by the length.



113. BOX, WITH BACK BOARDS AND CLAMPS

Another Method. Another way, though not quite so ready, is to deduct the *area* in inches of the inner diameter from the area in inches of the outer diameter, which gives the area in inches of the annular ring included between them, and this, then, is multiplied by the length. To obtain areas of circles, the exact rule is: square the diameter, and multiply by ·7854. To obtain areas mentally an approximate method is to square the diameter, and deduct $\frac{1}{4}$ from the product. In a plate 12 in. diameter and 1 in. thick, this would produce an error of only 2·3 in., or a little over $\frac{1}{2}$ lb. in weight.

After a pattern has been divided up into sections, and each calculated, the *sum* of the cubic inches is taken, and multiplied thus: Exact; Cubic inches × ·263 = lb. Approximate; $\frac{\text{Cubic inches}}{4}$ = lb. This is incorrect to the amount of 1·8 lb. on a plate 12 in. square and 1 in. thick, being that much below the correct weight, but is accurate enough for work not very heavy. Or allowance can be made thus: $\frac{\text{Cubic inches}}{4}$ and add $\frac{1}{20}$ of the product, which will give exactitude again. The difference between using ·263 and ·26 is only equal to ·4 lb. on a plate 12 in. square and 1 in. thick. For bringing pounds into cwts. ·009 is simple and correct



114. SNAP FLASK

Continued

SELLING & FEEDING LIVESTOCK

Auctions and Markets Compared. The Sale Direct to Dealers and Butchers. Proportions of Albuminoids, Carbohydrates, Fats, and Minerals in Foods

continued from page 2627

By Professor JAMES LONG

SELLING LIVESTOCK

The sale of the livestock of the farm is much less easy and satisfactory than the sale of corn. With samples in his pockets, the farmer may visit the corn exchange in any neighbouring market town, or millers and corn merchants, as he may judge best, but in the sale of his livestock much more is involved in the form of labour as well as in the form of judgment. A sample of corn may and should realise its actual value, for its valuation is comparatively simple, but both fat and store cattle, like milking cows, are almost invariably valued on a different basis by different individuals, and although a price is ultimately arrived at, whether at the auction mart or in the market, or as between a buyer and seller, there is seldom the same satisfaction as a result of a completed transaction. This is owing to various causes, as, for example, the weight of the actual carcase of a fat animal as butcher's meat, its quality, which can seldom be determined with real accuracy while the animal is living, the value of the offal, and the actual market value per stone, per score, or per cwt. It may be added, too, that the weights of beasts, as of dead meat, are reckoned in different terms in different parts of the country. In one district both farmer and butcher think and calculate in stones ; in others, in scores ; in others, in cwts.—these being mere examples ; and where the buyer estimates weight or value in one term of figures and the seller in another term, the difficulty becomes more complicated.

The Auction. We may briefly assume that there are four methods of selling livestock—by auction ; in the open market or fair ; direct to the dealer or the butcher on the farm ; and through the medium of advertisement. The auction is now a very general institution. It is usually conducted by an independent auctioneer on market day, this gentleman running the business for his own profit ; but in a small number of cases farmers have combined, and run an auction of their own with the co-operation of a paid auctioneer. This lan is generally a good one, and should be xtended in all parts of the country. The auctioneer has nothing to gain by leaning to the ealer or encouraging rings of dealers and utchers, which he is sometimes obliged to do hen working on his own account, in order to cure and retain their patronage, for without e attendance of dealers many auctions would uickly go to the wall. Unless an auction sale well attended, it is next to useless for farmers send stock, even though they place reserve ces upon them. The buyers at the auction chiefly dealers, butchers, and farmers. The butchers buy for slaughter, the dealers for re-sale to their customers—farmers and butchers alike—or sometimes for the purpose of taking their purchases to other markets where they anticipate realising higher prices. This plan, however, is a matter of speculation, and is justified only by the intelligence and expertness of the dealer. The stock sent to the auction mart chiefly consist of horses, fat cattle, calves, sheep, and pigs, store cattle and store sheep, and here farmers are frequently able to buy breeding stock, or stock for summer grazing or winter feeding, at reasonable prices and under conditions which before the establishment of auctions were non-existent. It is always well, however, to learn as far as possible to whom undescribed stock belongs in order to avoid being run up by dealer-owners or by rings of dealers, who sometimes combine for this purpose.

Open Markets and Fairs. Stock is sold in the open market in almost all market towns, and at the occasional fairs which are held in different parts of the country. It is, therefore, important to a farmer to be sufficiently near several market towns that he may be able to avoid driving his stock long distances—a practice which involves expense on the one hand, and loss of condition on the other. Fat pigs are usually drawn to market—a plan which should be followed as far as possible with fat sheep and calves ; but, as a rule, cattle and sheep, whether in store or fat condition, are driven sometimes long distances, with the result that they may arrive empty, perspiring freely, with dusty, ragged coats or fleeces, and altogether unpresentable. In such cases considerable losses may result from a faulty or careless system of management. To realise their full value, stock sent either to market or auction should be presented in clean and good condition. Abundant time should be allowed for the journey, and, if the animals are allowed to graze and drink on the roadside quietly and leisurely, so much the better for the result. An animal should enter the sale ring—and the remark applies equally to the open market pen—sleek, quiet, contented, and well filled. It is difficult enough to obtain the value of stock under such conditions, but it is impossible to do so when condition has been lost, even though the loss be temporary. Fat stock is frequently sent to the great London and other markets by farmers, who place them in the hands of salesmen, but a salesman acting as it were as agent is not always to be relied upon. Where a consignment is important, the farmer should himself attend the market and see precisely what happens.

Sale of Slaughtered Stock. In some cases fat stock are slaughtered on the farm—and this frequently happens to swine—and consigned to salesmen in the meat market, who, upon application, send baskets for the purpose of packing. On application, too, quotations may be obtained as to price, but the farmer will be wise to ignore figures, which the salesman would himself be the first to ignore if it pleased him. On receipt of the account, the price remitted may be less than the quotation, an explanation being given to the effect that the market was bad, or that prices had fallen. Again, however carefully carcases may have been weighed—and weighing should never take place until they have cooled—it may be found that the weights as shown by the butcher on his account and those taken on the farm are entirely different, and always in favour of the butcher. For these, among other reasons, it is difficult to recommend the practice of consigning carcases to the wholesale market. In all cases, however, it should be emphatically understood that price depends very largely upon quality and condition.

Where cows are sent into the market they should be of the type demanded by the buyers of the district. Large, big-framed cattle are preferred, of good quality—a great point with many buyers—young, vigorous, healthy, in thoroughly good condition, with large, well-filled udders, showing evidence of milk-producing power, and of such quality of flesh as would be likely to make good butcher's meat when the time arrives for fattening.

Selling Direct to the Butcher. Where a farmer is able to arrange with a dealer or a butcher, he will find this one of the simplest and best methods of disposing of his stock. A neighbouring butcher, who can depend upon being supplied with a good article, is often willing to pay a better price than other people, and he is worth considering and accommodating if he is willing to buy with regularity. There are, too, many dealers who drive from farm to farm, and who will call and make regular purchases if they are liberally treated. It is at all times worth considering whether attention may not be advantageously given to such men, and frequent expeditions of master and stock to market altogether avoided. In selling to a butcher, the stock should be sold by weight, and the weighing of the carcases conducted in the presence of the owner, a price per stone having been agreed upon. If, however, the butcher prefers to buy at a fixed price per animal, the farmer should learn to judge value by weight, and in this case a weighbridge becomes essential. Having ascertained the live weight, it becomes necessary to estimate the carcase or dead weight, in accordance with the condition of the animal, whether half-fat, or fat. Some farmers are excellent judges of weight; others, with confidence in themselves, are bad judges, and frequently lose in consequence of pitting themselves against the much more experienced butcher or dealer.

Pedigree Stock. Where the farmer breeds pedigree stock, or stock of a specially good type intended for reproductive purposes, he may find many customers who will pay him more than market price for what he has to sell through the medium of advertisement. Advertisements should be frequent and explicit, but it is next to useless to adopt this method of selling unless the stock offered is good, and can be shown in fine condition. Intending buyers may be expected to pay visits of inspection, and practically the only incentive to complete a purchase is given when they see before them something which is really attractive, as well as supported with a good pedigree. A really good animal, when young and in fine order, will sell itself. It is folly to keep animals intended for sale when they are at their best.

PRINCIPLES OF FEEDING

Farm animals and their produce are, to a large extent, what they are made by man's ingenuity in the process of selection and feeding. Down the ages through which agriculture has been practised, experience has done much to economise production, but it is probable that more has been accomplished during the past century in the one case, and in the past thirty years, in the other, than during all time. It has hitherto occupied a large portion of the life of a farmer to acquire by experience sufficient knowledge for his purpose in the matter of feeding, whereas to-day, owing to the results of scientific investigation, it is possible to master the principles of feeding in as few months, and thus to start with a definite purpose on practically secure ground. A growing plant collects from soil and atmosphere materials which it transforms into various compounds, and which, when consumed by animals, are converted into meat, milk, wool, and hair, among material products, and energy, to which reference will presently be made. What, then, are the materials upon which plants draw or feed for these purposes?

Materials on which Plants Feed. Among the chief are carbon (appropriated in the form of carbon dioxide, or carbonic acid), calcium (which combined with oxygen forms lime), potassium, sulphur, phosphorus, sodium, magnesium, and iron. Carbon, which forms the largest proportion among the constituents of plants, has been estimated to be present in the atmosphere in its combined form to the extent of 7¾ tons over every acre of land, while nitrogen, which forms so large a proportion of the atmosphere, and which is the most expensive of the fertilising elements, is, so far as is at present known, directly appropriated by plants of the leguminous order alone, such as beans, peas, and clover; the property they thus possess practically doubles their value to the farmer. As we have already seen, the growth of crops involves on all old soils, such as those of the British Isles, the application of manure. The principal reason why this application is necessary is that three of the constituents essential to plant life and growth are, so far as their availability is concerned, removed from the soil so rapidly and so effectually—this fact applies in many cases to lime as well—that, unless they are returned

in the form of dung or chemical fertilisers, the soil becomes exhausted and refuses to grow a profitable crop. These materials are nitrogen, phosphoric acid, and potash.

Animals are fed upon foods which exist in great variety. They include the dry fodders—hay and straw—the cereals, the pulses, roots, grasses, and other green crops, and the cakes, chiefly the residue of linseed, cotton-seed, palm-nut, cocoanut, rape, sesame, and others, from which the oil has been largely extracted. It is largely owing to the employment of the cakes, pulses, and cereals that high feeding is possible, and that the early maturing of stock for the butcher has been so successful in practice.

Maintenance Rations. Food may be supplied to the animal for the purpose of maintenance alone, or for maintenance plus increase in weight, involving the production of meat or the manufacture of milk. In either case it is well to understand in what a maintenance ration consists. Maintenance practically means provision for the maintenance of the natural heat of the body—the expenditure of force and energy which is most marked in the horse, and the repair of muscle and other tissue. When we add to the maintenance ration additional food, we provide for the growth of the fœtus in the pregnant animal, for the growth of the young, for the production of meat, and for the manufacture of bye-products, such as milk and wool. Owing in part to the difference in the structure of the various animals on the farm, different foods or combinations of food are supplied to stock in accordance with their special requirements. Thus the horse is fed to enable him to draw heavy weights or to travel at high speed, while the dairy cow is fed for the production of milk. And thus it is that knowledge of the composition of foods, their market and manurial value, are so essential to both breeder and feeder. The food of an animal, unlike that of a plant, which is built up by the aid of certain constituents of the atmosphere, a very small proportion of the mineral matter of the soil, and water, must be practically ready-made, and composed of such substances, and in such proportions, as will maintain the normal temperature of its body, provide for the waste of tissue, and the expenditure of energy. The materials present in food which meet these requirements are known as protein, carbohydrates, and fat, and science has determined, without laying down an inflexible law, what quantities of each are necessary in the provision of rations for horses, cattle, sheep, and pigs of given weights. The proportionate supply as between the digestible protein and the digestible carbohydrates—for neither are completely digested—and fats, is known as the albuminoid ratio.

Protein. Protein is the only food constituent which contains nitrogen; hence it is sometimes described as nitrogenous matter. It includes the albuminoids, the specially nutritious nitrogenous constituent of stock foods, and the amides. The albuminoids provide for the manufacture of the muscular tissue, digestive organs, skin, horn, hoof, and bones, of which nitrogen forms an important part. It is also possible that they contribute to the formation of fat owing to their richness in carbon (55 per cent.). For a similar reason it is believed that the albuminoids assist in the provision of heat and energy. They include the gluten of grain, the legumine of peas, beans, and other plants of the leguminous order; the casein of milk, and the albumin of the egg. The elements of which the albuminoids are composed are carbon, oxygen, hydrogen, and nitrogen, sometimes with the addition of sulphur and phosphorus. The nitrogen compounds known as *amides* also undergo combustion, and produce heat and energy in the animal body, but there is reason to believe that they exert no influence in the formation of flesh. Foods rich in albuminoids, like foods rich in oil, are costly; hence the importance of producing them on the farm, and of simultaneously providing for the feeding of the stock and the soil, for the reason that where a leguminous crop is grown the soil is enriched by the nitrogen in its roots. Although the albuminoids are rich in carbon, it would be folly on account of their cost to employ them as food fuel, for the carbon of food undergoes combustion in the animal body as certainly as the carbon of coal in the furnace. The coarser foods of the farm—hay, straw, and roots in particular—which are rich in carbohydrates, consequently provide carbon at a much smaller cost.

Carbohydrates. Carbohydrates, the chief of which are starch and sugar, are composed of the elements carbon, hydrogen, and oxygen. They are sometimes described as heat-giving or carbonaceous foods, a term which, as we have seen, may be equally applied to albuminoids and the fats. The carbohydrates, however, are more than heat-givers, for they are the principal source of energy, and it is chiefly for this reason that they are provided in stock rations in much larger quantities than either the albuminoids or the fats. Starch and sugar, like cellulose, the material of which the cell walls and fibrous matter of plants are chiefly composed, are abundant in all classes of food, and are for the most part highly digestible. They are believed to be chiefly responsible for the production of fat.

Fats and Oils. The fats and oils produce upon combustion some 2·29 times as much heat as the carbohydrates sugar and starch, for the reason that they contain a much larger percentage of carbon; but, unlike starch, they form a portion of the animal body, and possibly are in part deposited as animal fat without undergoing any marked change. The fat of food, in addition to its property of providing heat, energy, and animal fat, is a valuable digestive, and a ready means not only of increasing weight, but of contributing to the appearance and condition of stock of all kinds. It assists, too, in preventing a waste of the albuminoids, for in the absence of a sufficiency of carbohydrates the animal would draw upon the carbon and hydrogen of the albuminoid matter it consumed.

Mineral Food. Reference has been made to the mineral constituents of plants. These are practically essential to the animal, inasmuch as they provide for the construction of the bones and the manufacture of the digestive juices, the former containing phosphoric acid and lime, and the latter soda and chlorine. The milk of the cow, too, is rich in the mineral matter necessary in the building up of the young animal.

Foods are not all digested. Practically speaking, portions of each constituent pass through the system unappropriated, and it is, therefore, essential to know not only the names of the most economical and essential foods, but the proportions of each of their constituents which are digestible and nutritious.

The tables on this page which include the chief stock foods arranged in their several divisions, show the approximate percentages of water, digestible albuminoids, carbohydrates, and fats.

The foods rich in oil or fat are linseed (35 per cent.), cotton-seed (27·3 per cent.), palmnut (48 per cent.), linseed cake, cotton-seed cake, cocoanut cake, maize-germ meal, rice meal, palmnut cake. Foods rich in ash, or mineral matter, vary from 0·7 per cent. in roots to 10 per cent. in rice meal, and 7 per cent. in rye grass, clover, good meadow hay and vetch hay; the straws, chaff, and the leading cakes, all of which are rich in the same materials. The figures which have been supplied here at once indicate which foods are the most concentrated and the most valuable. If we add together the percentages of albuminoids, carbohydrates, and fat, we are enabled still further to ascertain which foods provide the largest amount of nutritive matter, and, therefore, guided by market prices, which, in most cases, are the most economical. For instance, if we desire to choose between maize and oats, not being tied by any consideration for the provision of albuminoids, we find that while maize contains 73·8 per cent. of digestible nutritious matter, oats only contain 57 per cent. Thus, supposing both foods cost the same sum—say, 2s. 6d. per bushel—the maize weighing 60 lb. per bushel supplies 44¼ lb. of nutritive matter, while oats weighing only 40 lb. in a good sample—38 lb. being more common—provide only 22¾ lb. of nutritious matter, or almost precisely one-half. In such a case the food in the oats would cost double as much as the food in the maize, as we have fully explained elsewhere. We have always, however, to consider the importance of the albuminoids where they are not provided in the fodder of the farm, and still further—to take an important example—in feeding a horse we have to remember that owing not only to its higher percentage in albuminoids, but to the presence of a larger quantity of husk and its consequently greater safety, the oat possesses a mechanical value which adds something to its economic worth.

Relative Values of Foods. In purchasing a food, it is sometimes useful to estimate its relative value as compared with other foods by the adoption of a system which, making

Foods.	Water	Digestible. Albuminoids.	Carbohydrates.	Fats.
NITROGENOUS DRY FOODS				
Linseed cake	12·2	24·8	27·5	8·9
Decorticated cotton-cake	11·2	31·0	18·3	12·0
Common cotton-cake	11·3	17·5	14·9	5·5
Palmnut cake ..	10·5	16·1	55·4	9·5
Rape cake	11·3	25·3	23·8	7·7
Cocoanut cake ..	9·4	18·2	47·4	11·2
Sunflower cake ..	10·3	31·3	24·7	7·6
Sesame cake ..	11·5	28·0	16·1	10·4
Beans	14·5	23·0	50·2	1·4
Peas	14·3	20·2	54·4	1·7
Lentils	16·5	21·4	46·0	2·2
Wheat bran (coarse) ..	12·9	12·6	42·7	2·6
Malt combs	10·1	19·4	45·0	1·7
Brewers' grains ..	76·6	3·9	10·8	0·8
Desiccated grains ..	12·0	19·1	42·0	8·5
Shorts, or middlings	12·5	10·8	44·8	2·8
NITROGENOUS GREEN FOODS				
Red clover (in full flower)	80·4	1·7	8·7	0·4
White clover (in full flower)	80·5	2·2	7·9	0·5
Alsike clover (in full flower)	82·0	1·8	6·9	0·3
Lucerne (in flower)	74·0	3·2	9·1	0·3
Sainfoin	81·4	3·0	7·9	0·5
Crimson clover ..	81·5	1·5	7·5	0·3
Vetches	82·0	2·5	6·7	0·3
Peas	81·5	2·2	7·4	0·3
Rape	87·5	2·0	4·8	0·4
DRY FODDER				
Lucerne (good) ..	16·5	12·3	31·4	1·0
Sainfoin	16·7	7·6	35·8	1·4
Vetch hay (medium)	16·7	9·4	32·5	1·5
Red clover (medium)	16·5	10·7	37·6	2·1
CARBONACEOUS DRY FOODS				
Wheat	14·4	11·7	64·3	1·2
Barley	14·3	8·0	58·9	1·7
Oats	14·3	9·0	43·3	4·7
Maize	14·4	8·4	60·6	4·8
Malt	7·5	7·5	62·8	1·6
Ricemeal (good) ..	11·5	11·2	52·9	13·9
Maize germ-meal ..	11·9	10·5	44·0	14·8
Buckwheat	14·0	6·8	47·0	1·2
Rye	14·3	9·9	65·4	1·6
Meadow hay (poor) ..	14·3	3·4	34·9	0·5
Meadow hay (good) ..	15·0	7·4	41·7	1·3
Rye hay (good) ..	14·3	6·6	44·3	1·3
Perennial ryegrass (good)	14·3	5·1	35·3	0·8
Wheat straw ..	14·3	0·8	35·6	0·4
Rye straw	14·3	0·8	36·5	0·4
Barley straw (summer)	14·3	1·3	40·6	0·5
Oat straw	14·3	1·4	40·1	0·7
Vetch straw	16·0	3·4	31·9	0·5
Pea haulm	16·0	2·9	33·4	0·5
Bean straw	16·0	5·0	35·2	0·5
CARBONACEOUS GREEN AND OTHER SUCCULENT FOODS				
Potatoes	75·0	2·1	21·8	0·2
Mangels	88·0	1·1	10·0	0·1
Carrots	85·0	1·4	12·5	0·2
Turnips	92.0	1·1	6·1	0·1
Swedes	87·0	1·3	6·3	0·1
Parsnips	88·3	1·6	11·2	0·2
Green maize ..	82·2	0·7	8·4	0·3
Cabbage	89·0	1·1	6·0	0·2
Kohl Rabi	85·0	2·0	7·7	0·4
Pasture grass (average)	80·0	2·5	9·9	0·4

allowance for the fluctuations of market prices, is a help to the buyer; we refer to what is known as "unit value," which, however, is more commonly applied to the purchase of artificial manures. A unit of albuminoids has been estimated to be worth 2s., of carbohydrates 1s., and of fat 2s. 6d. Thus, supposing we take maize to illustrate our case. We find from the figures in the table that this cereal contains, roundly, 8·4 per cent. or units of albuminoids which at 2s = 16s. 9d., 4·8 per cent. or units of fat which at 2s. 6d. amounts to 12s., and 60½ units (60·6 per cent.) of carbohydrates at 1s., or £3 0s. 6d., giving a total of £4 9s. 3d. One ton or 4⅝ quarters of maize at 20s. would equal £4 12s. 6d. Taking a series of years—although prices have been higher of late—20s. is about the average cost of maize purchased wholesale, so that at this price a ton the quantity with which we are dealing in the calculation would cost but little more than the valuation. If similar calculations are made as applicable to other foods, wider differences may appear, but it is always important to add the manurial value of the food on the basis of the estimated proportions of the nitrogen, phosphoric acid, and potash obtained from it, and voided in the solid and liquid excrement of the animal. [See page 589.]

Compound Foods. In purchasing compound foods, such as cakes and meals, it is important that the buyer, guided by the Fertilising and Feeding Stuffs Act, which was passed for his special protection, should submit a sample to the public analyst, appointed for the purpose, for analysis. He will, under defined conditions obtainable from the Board of Agriculture, or from the Act itself, be required to send a duplicate sample to the vendor, together with notice of his intention, and if, as should have been the case, he obtains a guarantee of purity or quality, he will be in a position to obtain compensation should the article he purchases not correspond with the analysis. Although the best makers and merchants may be trusted, there are so many cases of deliberate fraud or loss, the result of ignorance, on the part of vendors that no exceptions should be made in this matter, especially as every County Council retains an analyst who conducts the work at a nominal fee. The loss sustained by a purchaser of an inferior or adulterated food is not confined to the difference in market value, for if purchased in large quantities his stock may suffer to an extent which may not be readily understood. Analysis is not arbitrary so far as regards the percentages of food constituents, inasmuch as samples differ, although in a minor degree, and this applies not only to manufactured or compound foods, such as cakes and meal, but to grain, hay, roots, and practically every crop that grows.

Digestibility of Different Foods. One of the most important features in dealing with such figures as most tables of analysis supply is to remember that it is the digestible constituents, and not the total constituents or dry matter of food, which are of importance. Young grass is much more digestible than older grass; finely cut, crushed, ground or steamed food than whole, raw, or coarse food; and slightly fermented mixtures of roots, chaff, grains, meal, and cake than the same foods fresh and cold. The digestive juices are able to act with greater thoroughness upon food composed of fine particles than upon food which is coarse in character; and while individuality accounts for much, it is certain that rations given in small quantities, and carefully and finely prepared, are followed by the best results. Again, owing to the difference in the physiological structure of the digestive organs of cattle and sheep, as compared with those of horses and pigs, the two former require bulkier foods and a larger proportion of fibrous matter. It has already been pointed out that foods differ in their digestibility; and, further, that the digestive powers of different animals also vary; and that the cereals and young plants are more perfectly digested than dried fodders, such as hay and straw. The carbohydrates, starch and sugar, are practically all digested, although the starches of different plants vary in the time occupied in their digestion. Again, there is a difference in the digestibility of fats and oils; and although little is known which can be regarded as exact, it is believed that their absorption in the system of the animal is fairly complete. Something depends, too, upon the aroma of food and its flavour. If it is agreeable to the animal and is relished, the glands are stimulated, with the result that a marked influence is exerted on the digestive apparatus. Again, the larger the ration the more slowly is the food digested.

The Carcase. Let us now mention a few facts in relation to the carcase of the animal. In feeding for the butcher there is a percentage decrease of water, nitrogenous matter and minerals, with an increase of fat. Thus, owing to the diminution of the water percentage, a larger amount of food is produced in the carcase, although in the case of really fat stock this means considerable waste; for while the purchaser of a joint pays for the extra fat, he seldom consumes it. In a half-fat animal, the dry matter of the carcase is about equal to its water contents. Comparing the fat beast with the lean beast, there is a smaller proportion of the fertilising constituents of food, nitrogen, phosphoric acid, and lime in the former than in the latter. Thus, when fat stock are sold off the farm there is relatively less fertility carried away than when the animals sold are in store condition. Again, although the loss of the mineral fertilisers present in the carcase of a beast is in the gross really small in quantity, weight for weight, cattle sold off the farm take with them more than sheep, and sheep more than swine. The fertilising matter removed in milk and the crops of the farm—grain, pulse, hay, and the like—is much larger in quantity than that removed in fat stock, so that the feeder who consumes his own crops loses very little fertility. The cost of feeding Irish store cattle, which are so largely purchased by English farmers for fattening for the butcher, has been estimated to reach £17 at 2½ years old, while in Scotland the cost at 20 months is estimated at

£18 12s., these figures including insurance, interest on capital, attendance, and grazing.

The Albuminoid Ratio. The albuminoid ratio may be regarded as the proportion of digestible nitrogenous matter present in a food as compared with the carbohydrates and the fats estimated as carbohydrates. The opinions of experts differ to some slight extent as to the figures of the ratio, but we may take it that the ration supplied to the animals of the farm shall consist of one part of digestible albuminoids to from five to six parts of carbohydrates and fat, the fat being estimated as a carbohydrate by multiplying its percentage by 2·29, this being its relative heat and energy-producing capacity. Let us illustrate our case by an example taken from conscious life. A man taking average exercise requires about 4,500 grains (say, 10 oz.) of carbon and 300 grains (about ¾ oz.) of nitrogen daily as a maintenance ration. Suppose the food he consumes consists solely of bread, he would require 4 lb. daily in order to obtain the necessary nitrogen; but as 4 lb. of bread contains nearly 20 oz. of carbon, this system of maintenance would result in waste. Thus it is that a food like bread, which is rich in carbon, is eaten in conjunction with other foods taken in smaller quantities, such as meat, fish, or cheese, which are rich in nitrogen. Taking a number of authorities collectively, we find that on the basis of their investigations an average man doing a moderate amount of muscular exercise requires 120 grammes of protein, 500 grammes of carbohydrates, and 50 to 60 grammes of fat. See "Principles of Dietetics" (Hutchinson). Here, then, we get a ratio of 1 to 5·5. We remember an instance of a small farmer who fed a few cows solely upon mangels, which, apart from the unsuitability of their bulk, are extremely poor in albuminoids; but supposing the whole of the albuminoids in the mangel to be all digestible and nutritious—which is not the case—a cow of 1,000 lb. weight would have to consume nearly 250 lb. of the roots in order to enable her to obtain a sufficient quantity of nitrogen to meet her maintenance requirements alone. If, however, she were able to consume this quantity and to digest it, she would obtain 25 lb. of digestible carbohydrates, or about twice the quantity required in a mere maintenance ration.

The Value of Grass. Let us now take an example in order to show how the albuminoid ratio is calculated. Grass which, when good, is admirably balanced as a food for cows, will serve as an excellent example; it contains 2·5 per cent. of digestible albuminoids, 10 per cent. of carbohydrates, and 0·5 per cent. of fat. The fat is multiplied by 2·29, as we have shown. The result thus obtained is added to the carbohydrates and divided by the percentage of albuminoids. Thus:

$$\frac{10\cdot 0 + (0\cdot 5 \times 2\cdot 29)}{2\cdot 5} = 4\cdot 458,$$

so that the albuminoid ratio of *good* grass is 4·458, practically as 1 is to 4½; so rich is it indeed that grass of high quality may, therefore, be regarded as a nitrogenous food.

Food for a Cow. It has been laid down on the basis of many investigations, especially in Germany and the United States, that a cow weighing 1,000 lb. requires for the maintenance of her carcase and the provision of heat and energy 15·4 lb. of digestible nutritious dry matter, which, in terms of ordinary farm rations, is practically equivalent to 24 lb. of the organic matter of her daily food supply. Some investigators, however, slightly increase the quantity of dry matter. The figures referred to (15·4 lb.) should provide some 2¼ lb. of digestible albuminoids, 12¼ lb. of carbohydrates, and 0·4 lb. of fat, so that the albuminoid ratio would be as 1 is to 5·4. In the practice of the farm, rations frequently contain a larger proportion of the carbohydrates, especially where large quantities of straw, roots, and maize are used; while in other cases, especially during the summer season, when clover, vetches, and rich grasses are provided, the proportion of albuminoids may be very distinctly raised. The wisest plan, however, is by the adoption of the system of recording the weights and varieties of food supplied and the milk produced, to ascertain which foods are the most economical. So far, reference has been made to the provision of food for the maintenance of a cow. When she is in milk, however, she requires, in round numbers, an additional pound of digestible dry matter for every gallon she produces. Thus, an animal yielding 5 gallons per day—a rather exceptional quantity—would require, on the basis of Wolff's figures, 20·4 lb. of digestible dry matter of similar composition.

Scientific Feeding. Much, however, as investigation and experiment has accomplished, we should regard these figures as merely indicative of what science has so far been able to teach us, and the farmer who, while adopting the principle, experiments for himself, may possibly find that he obtains more economical results, especially when he produces his own food-stuffs, by the provision of slightly larger quantities of the carbonaceous foods on the one hand, or of the nitrogenous foods on the other. Where it becomes essential to purchase foods which are rich in nitrogen, they should be used sparingly on account of their higher cost, for they are only required for their nitrogenous constituents, the much less costly carbohydrates being obtainable on the farm, or at little cost on the market.

In purchasing foods it is well to guard against those which contain large proportions of indigestible matter. The value of food is chiefly in proportion to what is actually absorbed by the animal's economy, and especially should we remember that there are portions of the albuminoids which are never oxidised and which pass away in the urine. Another source of loss is found as the result of the fermentation of bulky foods rich in carbohydrates. Gases are produced, and the energy value of the food is lost; hence the importance of thorough mastication, of well-prepared and appetising rations, and of good digestion, which we expect to find in stock of robust and healthy character.

Continued

SEWING THREAD MANUFACTURE

Group 28
TEXTILES
19

Continued from page 2598

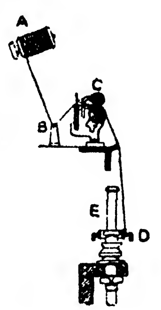
Sewing Thread. Twisting or Doubling. English Dry and Wet Doubling and Scotch Doubling Systems. Dressing. Gassing and Spooling

By W. S. MURPHY

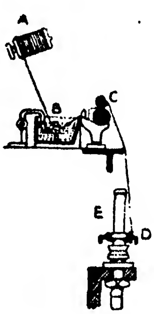
SEWING thread manufacture is the highest form of doubling; the thread maker is alone the complete doubler. In the thread factory all the processes of doubling are summarised. No other industry exhibits so clearly the strength of capital in modern manufacture. An essentially simple process, involving few exclusive patents, open to anyone who likes to start, thread manufacture is dominated by three world-embracing syndicates, and, up to the present, no one outside the syndicates has a chance. The names of the companies are: J. and P. Coats, Limited; English Sewing Cotton Company, Limited; American Thread Company, Limited. The competition of the three companies is practically nil; they have each a defined sphere.

In thread manufacture we use very high counts of yarn, sewing thread running from 60's up to 300's. Machine threads call for lower counts, ranging from 30's up to 80's. As a rule, the yarns come in hanks, and the first operation of thread manufacture is winding. This being a simple operation, we need hardly delay over it. As has been shown, the winding is performed almost automatically.

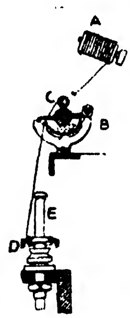
Twist- The ins ken to he ing rt- Ma- sew- ing threads need very little twist, and the twisting of these is done on the mule. Sewing threads however are produced on the frame by the ring traveller. But this is something more than a spinning frame [112]. Note the differences. From the top creel, on which three, four, five, or six rows of bobbins are set, the threads are led through guide eyes, and all the threads of each set are combined together in the doubling rollers. Below the rollers, in the wet doubling frame along the whole length of the frame, lies a shallow trough full of hot water. Passing through this, the cords come down through the ring traveller on to the bobbin. As in the spinning frames, the traverse rail moves up and down, distributing the thread evenly over the bobbin.



109. ENGLISH DRY DOUBLING SYSTEM



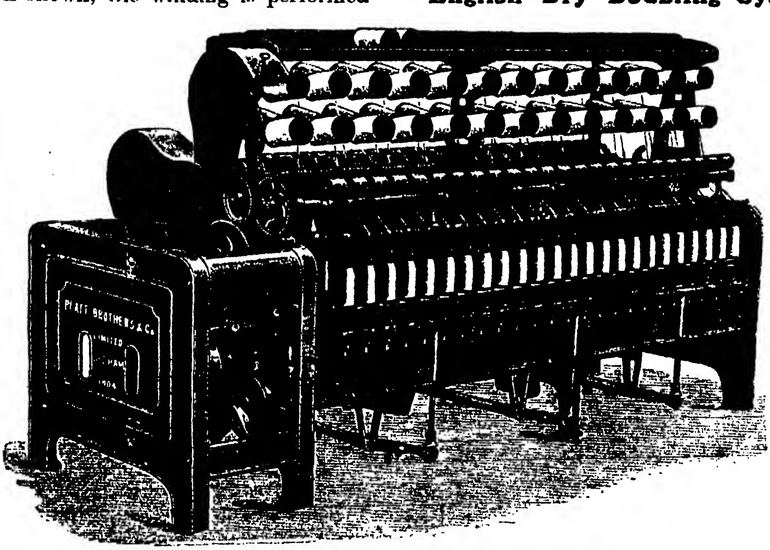
110. ENGLISH WET DOUBLING SYSTEM



111. SCOTTISH SYSTEM OF DOUBLING

Different Systems of Doubling. While the principle of doubling or twisting is readily understood in its general application, there are different modes of application to which some attention should be paid. The three principal systems are: (1) English dry system; (2) English wet system; (3) Scotch system. We are indebted to Messrs. Hetherington & Sons, Manchester, for the diagrams illustrating the three systems.

English Dry Doubling System. In this system [109] the yarn comes from the bobbin A, and passes under the iron rod B, and over a glass slit guide through the rollers, and round the roller afterwards encircling a small glass pillar, and again passing through the rollers and down



112. RING DOUBLER FOR WET OR DRY WORK

on to the ring traveller D, and round the bobbin on the spindle E. The upper roller is made of polished cast iron, and the bottom roller is of fine steel.

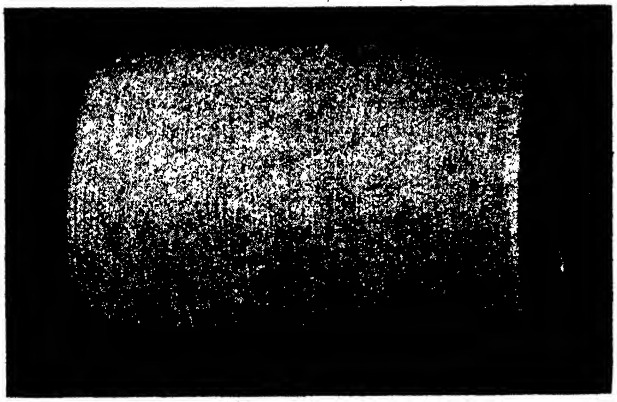
English Wet Doubling System. On this frame [110] the yarn is brought down from the bobbin A, and in under a glass rod B, which is set in the water trough. Next the yarn, now wet, passes through the guide on to the roller C, into the clasp of the traveller D, and thence round the bobbin E. The water troughs are placed behind and independent of the rollers, and may be in short lengths of copper, wood, zinc, or porcelain. Alternatively, if it be preferred, the troughs may be made the whole length of frame, with taps at the ends for filling or running off the water. The short troughs are more easily cleaned and attended to, but the long troughs are sometimes preferred.

Scottish System of Doubling. One distinctive feature of the Scottish frame is that it has always the trough of water. We do not say, however, that the Scottish doublers use no dry doubling frames. On the contrary, even the wet frame can be converted very simply into a dry doubler. The Scotch system is simpler and more direct than either of the English systems, though that may not always be a merit. The diagram [111] clearly shows the difference. Coming from the bobbin A, the yarn passes through the guide eye into the trough B, and round under the brass roller revolving in the trough, and up round the top roller C, thence to the traveller D, and on to the bobbin E. The trough is continuous through the whole frame. We have to note specially the rollers. The roller in the trough is hollow brass, of 2½ in. diameter, and can be raised out of the water by means of a worm gear and handle placed at the end of the frame. The top rollers are solid and brass-covered, and of 1½ in. diameter.

It must be understood that though the diagrams show only one bobbin delivering the yarn, there are, in actual practice, as many bobbins as there are threads to be doubled. In each case the separate threads join at the first point of contact on the frame, and run together through the operation.

Two-coloured and three-coloured threads are twisted dry, on either the mule or the ring traveller frame.

White sewing threads are bleached; coloured threads are dyed. Many firms hand over this work to others. But even when we elect to carry through the whole process, those operations are wrought in separate establishments. [See DYEING.]



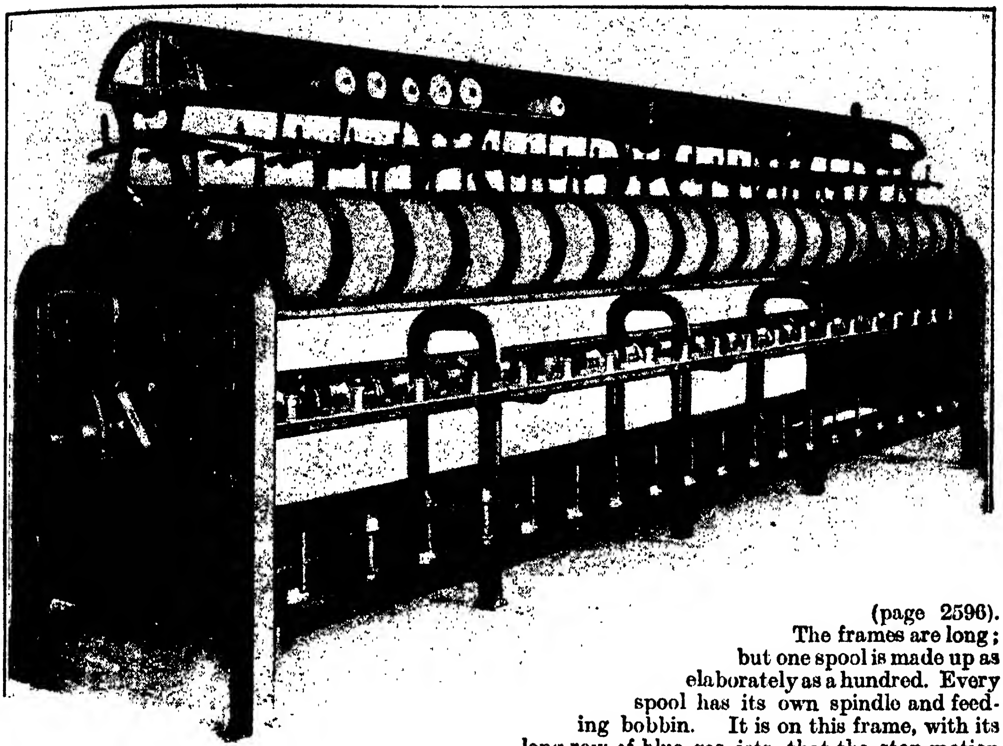
113. COTTON REEL

Dressing. When the threads come back from the bleacher, they are raw and harsh. Nobody would buy those threads. The bleacher has, we may suppose, wound our threads on to the bobbins again, and the bobbins are hung on the bank of the dressing machine. A bank is a high frame fitted with horizontal spindles to hold the bobbins in such freedom as allows the thread to come off easily. From the bank the threads are led through a comb, and in between a pair of rollers revolving on the brink of a vat containing hot size. A roller in the centre of the vat bears the range of threads down into the size, and as it emerges at the other side, a pair of heavily-clothed rollers clear it of superfluous liquid. Next, the threads wind in spiral fashion round a cylinder steam-heated within, and at the second turn pass between circular brushes which rub them clear. A pair of heated brass rollers now draw the slender white cords on and burnish them. At the end a bank with a winding apparatus winds the thread on to the spools again.

Gassing. *Spooling* is the next general operation; but for fine threads we have a process properly named *gassing*. As a rule, gassing is performed on the spooling frame; but it may be as well to study it by itself. Even after all our dressing, brushing, and burnishing, infinitesimal little ends of cotton stick out from the thread. One is almost invisible, but they are there by the thousand on every inch, and give a rough appearance to the finely-drawn cords. Various methods have been devised to remove this fluff; but burning by gas is the only way which has yet been found to produce satisfactory results. The heat from pure coal gas is both very strong and diffusive. Passing thread of delicate texture through a very small jet of such gas, even at the highest speed practicable, would be sure to scorch. But a current of air can be introduced into gas to cool it. The threads are passed through the flames of bluish colour, and emerge quite white, yet freed from all fluff.

Spooling. Conditions of climate, national custom, and use, determine the form of the sewing-thread spool. On that account, we have a large number of spooling machines—some, indeed, should be called *balling* machines. But we can safely consider the whole lot in three classes—the cross winders, the split drums, and the common horizontal spooling machines.

Cross Winders. About the winders we have little to learn. Geared to run at very high



114. SPLIT DRUM WINDER
(Wm. Whiteley & Sons, Ltd., Lockwood)

speed, and with a cam or an eccentric plate acting on the guides which distribute the thread on the bobbin, or spool, these winders are easy to manage; in fact, they have been so well contrived as to work almost by themselves.

Split Drums Spooling Frames. More interesting are the split drums spoolers [114]. The bobbin with the dressed thread is slung at the head of the machine, and the thread is led through the split in a drum to the spool in front. The drum is split in scallop fashion, the line curving from side to side. In its passage through the drum the thread is carried from side to side, distributing evenly all over the spool. Revolving under a heavy roller, or cylinder, the spool takes on the thread, the weight of the cylinder making a very firm and compact roll of thread. All the motions being direct, this machine can develop a high rate of speed.

Combined Gassing and Spooling. For the bobbins or spools in common use among ourselves, the combined gassing and spooling machine is mostly utilised in thread factories. It is almost identical with the cleaning and gassing machine already illustrated in 105 (page 2596). The frames are long; but one spool is made up as elaborately as a hundred. Every spool has its own spindle and feeding bobbin. It is on this frame, with its long row of blue gas jets, that the stop-motion principle is to be seen working to perfection. Connected with the driving gear of the spindle is a wire, not unlike a lady's hairpin, supported by the passage of the thread. When the thread slackens or breaks, the wire falls, and throws the spindle out of gear. The gearing of the spindle can be set to run out 200, 300, 400, 500, or 600 yd. of thread. If it were to run on after the thread had ceased to run, the number of revolutions of the spindle and the amount of thread on the spool would not correspond. Confusion would thus arise from the very appliances devised to make order sure. The finished spool [113] is a compact and neat bobbin, round which the thread lies firm and close. Before going out to the public the spool is labelled and otherwise finished.

There are several little points in the thread industry, and on the machines, which might be worthy of note, if it were possible to show them on the machines themselves; but that is beyond our scope. But after all has been shown, the wonder yet remains that so great wealth as has been won in thread manufacture could have been acquired in a process so simple. One could make a thread factory of a four-roomed cottage.

Continued

Group 5 CHEMISTRY 19 Continued from page 2554	ORGANIC CHEMISTRY

Continued from page 2554

ORGANIC CHEMISTRY

What is Meant by Organic Chemistry. The Power Within Living Things. The Plant as a Synthetic Chemist. Biochemistry. The Carbon Compounds

By Dr. C. W. SALEEBY

THE conception of chemistry as divided into inorganic and organic is almost as old as the science itself. It was conceived that there is an absolute distinction between chemical bodies characteristic of living matter and those found elsewhere. It could scarcely be maintained that the living body contained no substances found elsewhere, but those found elsewhere were regarded as, if not accidental, at any rate of scant importance. There remained many substances characteristic of the living body which, it was asserted, could be produced only by living agency. The whole question is so important, having a significance which far outsoars the bounds of chemistry, that we propose to deal with it here very carefully. The question is this: What are the grounds on which we declare that the division of chemistry into inorganic and organic is false and must be abandoned?

The Elements of Life. It is, of course, indisputable that the living bodies of animals and of plants contain chemical compounds, utterly beyond number, which are not met elsewhere. These compounds on analysis prove to be composed of elements already familiar to the chemist, while the number of organic compounds can be estimated only in billions of billions, these not being found naturally, except in the living body. The study of these compounds, in whatever number they are studied, reveals no element peculiar to life. So far as the elements are concerned, there is no foundation for the term *organic* chemistry. Elements constantly found in living organs there may be and are, but no element whatever not found elsewhere.

This is surely what we must expect. We may supply a plant with absolutely nothing but known compounds or elementary substances, such as oxygen, carbonic acid, nitrates, and the like; and we find that in these conditions, if provided with sunlight, it flourishes. The ordinary "inorganic elements" suffice—whether as elements or combined—for its nutriment. If it be killed and its body analysed, it reveals no other element.

Vital Force. This, of course, is a fundamental fact, and is a conclusion as significant as that of astronomical chemistry when it tells us that the elements of the stars are the same as those of the earth. But there remained the supposition that there is a special and unique power within the living body, whether of the animal or of the plant, which fashions its food so as to form compounds which can be produced by living organisms alone, and which may therefore be called unique. The process is entirely one of building-up, or *anabolism* or *synthesis*. Elements or simple compounds are supplied to the plant, and it combines them in such a fashion as to produce starch, sugar, albumen, or what not—which the chemist could not imitate. There is therefore, it was said, a "vital force," a thing incomparable with merely physical forces, and capable of doing what these cannot do.

In virtue of this force, the living organism, though it cannot make new elements and though it contains no elements peculiar to itself, can yet make new compounds, and is able to display compounds peculiar to itself—they said.

Vitalism. Thus the old distinction of chemistry into organic and inorganic depended upon the doctrine of vitalism, which asserted that living things are possessed of a unique force, independent of the law of the conservation and transformation of energy, and capable of accomplishing what even the sum of all the physical energies in the Universe could not accomplish. In this connection one cannot do better than quote from the recently-issued first volume of Professor Meldola's great work, "The Chemical Synthesis of Vital Products." The professor says: "If asked, as I frequently have been during the progress of the work, what position synthetical chemistry occupies with respect to the doctrines of vitalism or Neovitalism, I think it advisable to place upon record the opinion that the present achievements in the domain of chemical synthesis furnish no warrant for the belief that the chemical processes of the living organisms are in any sense transcendental, or that they must be regarded as belonging to a class of special material transformations which human science will never be able to reproduce. Such an admission as the latter would be tantamount to a proclamation of Neovitalism; but the whole history of organic synthesis, from the time when it was declared that organic compounds could be obtained only by living agency, is opposed to any such conclusion. But although the doctrine of a special vital force has received its death-blow at the hands of modern science, and although there is no warrant for the belief that the physics or chemistry of animals and plants is ultra-scientific, yet it must not be lost sight of that the synthetical possibilities of the living organism have brought us face to face with modes of chemical action of which we are as yet profoundly ignorant."

The point raised in the latter part of this quotation must, of course, be returned to. Meanwhile, we may content ourselves with this authoritative pronouncement as regards vitalism in its revelations to organic chemistry.

Pioneers. The year 1828 is usually regarded as furnishing the most important date in the history of this subject. It was in that year that Wöhler announced his discovery

that it is possible to construct the organic compound urea by synthesis from a salt called ammonium cyanate. As Professor Meldola pointed out more than ten years ago, equal honour must be accorded to an Englishman, Henry Hennell, who "succeeded in synthetising alcohol from olefiant gas at practically the same time as his great German contemporary had excited the interest of the whole chemical world by his synthesis of urea." In neither case was the argument perfect. Hennell obtained his olefiant gas from organic matter—oil, while the German attained his ammonium cyanate "by fusing nitrogenous organic matter with an alkaline carbonate." Only a few years later, however, the arguments were made perfect by the performance of the intermediate steps, and it was absolutely established that certain substances, hitherto thought to be producible only by the living body, could be built up or synthetised by chemists from their very elements. Nor was it necessary to obtain these elements from dead bodies; the nitrogen of the air was as effective for these purposes as nitrogen obtained by processes of decomposition.

The pioneers were bold men, so that, in 1838, the great Liebig and Wöhler dared to say—"From these researches the philosophy of chemistry must draw the conclusion that the synthesis of all organic compounds which are not organised must be looked upon not merely as probable but as certain of ultimate achievement."

The Father of Synthetic Chemistry. There still lives, when these words are written, the illustrious genius who may almost be regarded as the founder of synthetic chemistry. Of modern synthetic chemistry as a practical matter he is certainly the founder. This is Professor Marcellin Berthelot, whose jubilee has lately been celebrated in France. When he began his work, the great names in chemistry propagated sayings such as these. The great Swede Berzelius said: "Even if we should succeed in producing, with inorganic bodies, substances of composition similar to those of organic products, this mere imitation would give us no hope that we could ever produce the actual things themselves, as we succeed, in most cases, in confirming the analysis of the mineral bodies by effecting their synthesis in turn." And Gerhardt put the popular doctrine more effectively when he said: "The chemist does precisely the opposite of living nature; he burns, destroys, operates by analysis, while the vital force alone may synthetise. It rebuilds the edifice which chemical forces have broken down."

But Berthelot soon followed up the pioneer work of Wöhler and Hennell. He made alcohol and formic acid. He began to make fats and sugars; he showed that acetylene, now familiar as a gas for the lamps of motor-cars and so on, can be produced by direct combination of carbon and hydrogen when the electric arc passes between carbon poles in an atmosphere of hydrogen. This gas can be synthetised in half a dozen other ways, its formula being C_2H_2, and its original synthesis by Berthelot led to the making of innumerable compounds, including ordinary alcohol, benzene, and their numberless derivatives. Berthelot's greatest work appeared in 1860, and though he has lately devoted himself to many other matters, he remains the greatest of synthetic chemists.

The most distinguished of his successors is Professor Emil Fischer, of Berlin, who has mastered the making of the sugars, and even, as is far more significant, the making of certain bodies which are at any rate all but albuminous.

We may close our account of the history of the subject by reference to the large first volume of Professor Meldola's work from which we have already quoted. The number of vital products that have been made by artificial means ran into tens of thousands long ago, and the prophecy of Liebig and Wöhler is well on the way towards fulfilment.

New Compounds. Not only can an enormous number of vital products be made artificially, but the synthetic chemist has now learnt how to call into being a constantly increasing host of bodies which are closely allied to vital products, but which are entirely unknown in living or in lifeless nature. Of these, thousands and thousands are of interest at present to the chemist alone, but, on the other hand, many fulfil practical functions of the greatest value to mankind. Many most valuable drugs, inducing sleep, relieving fever, relieving pain, destructive to micro-organisms, and so on, have been thus produced, while of less importance are the many new dyes synthetically derived from coal-tar. Furthermore, the chemist is able to say that the vital products which he manufactures are strictly identical with those manufactured by the living body, and that such products, whether natural or artificial, are not only composed of the same elements as those found elsewhere, but that what we have previously described as the laws of chemistry are strictly observed. As we have said before, there are not two chemistries, but one chemistry, and any laws applicable to elements in the atmosphere are equally applicable to those elements when they occur in the body of an animal or plant living in that atmosphere. Similarly, all the laws of compounds and of chemical union and disunion, the laws of valency, and so on, are as true in the one case as in the other.

Plants are Consummate Chemists. Let us, then, abandon the term organic chemistry, find a new one, and proceed to discuss the substances that come under it. Such would seem to be the natural proceeding, and in the ordinary textbook of chemistry it is followed; but here we have a special aim. We desire not to isolate one science from another, but to co-ordinate them all. And for this reason we must consider a fact which is apt to be forgotten, though it is strictly a fact of chemistry, and though the unravelling of it would mean the making of a new epoch not only in chemistry, but also in the science of life.

Our argument here is practically confined to plants, and for this excellent reason—that the

animal body does not enter into competition with the chemist as regards synthesis. The animal body can effect synthesis only indirectly —when it comes to be inhabited by the mind of man, and when that man becomes a synthetic chemist. The synthesis, which was and is the puzzle, and which plays such an essential part in the economy of living nature, is effected by the plants alone. It has lately been shown that the animal body possesses a very small power of synthesis in certain cases, but though this must be noted, it is of no practical importance. It is the plant that is the consummate chemist. Alcohol and starch and sugar, the albumens, the volatile oils, and a host more, are its products, and the question is this: Having produced a large number of these substances without the intervention of the plant, and being doubtless able to produce any number more; being, further, able to produce a large number of substances which the plant cannot, or at any rate does not, produce, are we not entitled to dismiss the plant from our reckoning altogether?

Man's and Nature's Methods. But this would be the most unpardonable error. Whereas the chemist requires all sorts of powerful reagents, the production of high temperature, long periods of time in some cases, and so on, the plant is totally independent of such conditions. What the chemist produces by the electric arc and the sweat of his brow the plant produces in silence, without effort, at low temperatures, and at no obvious cost. We have scarcely begun to attack the true organic chemistry, and we can commit no greater folly than to suppose that our synthetic methods are identical with Nature's, or that because ours are known, hers are unimportant. Let us hear Professor Meldola:

"Those who consider that the triumphs of chemical synthesis have finally disposed of vitalism in any form will do well to bear in mind that until the chemist has shown that his synthetical methods are identical with Nature's methods there is just as much scope for endeavouring to penetrate the chemical vital mysteries as there was in the days when it was believed that every organic compound required an animal or a plant for its production. If this be lost sight of amidst the overwhelming mass of material accumulated by the great army of workers in the field of carbon chemistry, if we have produced thousands of compounds which do not and probably never will be found to exist in living organisms, if we have gone so far beyond Nature as to make it appear unimportant whether an organic compound is producible by vital chemistry or not, we are running the risk of blockading whole regions of undiscovered modes of chemical action by falling into the belief that known laboratory methods are the equivalents of unknown vital methods."

It is essential, as Professor Meldola points out, to turn back and ask ourselves how much light the synthetic chemistry of chemists has thrown upon the synthetic chemistry of plants.

Synthetic and Vital Chemistry. No synthetic processes which produce or involve flame or temperatures anywhere above, say, 103° F., have any particular bearing upon the real question. Says Professor Meldola: "The fundamental synthesis *par excellence*—the photosynthesis (synthesis by means of light), which plants are enabled to accomplish, and in the course of which carbon dioxide is absorbed by an organic compound and the product or products decomposed with the liberation of oxygen—is as yet without a laboratory parallel." Furthermore, while a very large number—perhaps the whole number—of vital syntheses are accomplished by means of enzymes or ferments, and while the majority of the more familiar products can be also produced in the laboratory, "the analogy between the natural and the laboratory process disappears when it is considered that as yet no organic nitrogenous agent of the nature of an enzyme has ever been synthetised."

It has now been shown by many authors that ferments or enzymes are involved in the building-up of a large number of compounds. Even though the stages may be followed by the synthetic chemist, yet the "actual vital method" has not been employed by him. We are bound in honesty to recognise these facts, and not to claim more than we are entitled to. Synthetic chemistry is of the utmost value on the philosophic score. It has clearly demonstrated that substances produced by the living body may be produced without its aid, thereafter exhibiting identical properties in every respect. But it has neither unravelled nor has it in any measure rivalled the synthetic processes as they occur in the living organism.

The Chemistry of Life. There remains a problem of the utmost importance, as the wisest of chemists themselves see. Only a few decades ago even a Liebig was content to say that the chemical processes of living matter demanded a vital force for their interpretation. The very last representative of this school of thought, Dr. Lionel Beale, F.R.S., has passed away a week before these words are written; and we must go a stage further.

But what is implied? Evidently this is implied. It is all very well for the chemist to deny the existence of vital force, and he is doubtless right. It is all very well for him to compete with the living organism. But is it not plain that if his processes are not the same as its processes, and if its processes are purely chemical or chemico-physical, and not peculiarly vital—there is a great kingdom of chemistry, not even the threshold of which has he yet reached? Of course, this is so; synthetic chemistry has done nothing, or almost nothing, to illustrate the chemistry of living matter. It has merely abolished the old explanation of a vital force, which, of course, was no explanation, but merely a case of darkening counsel by words without knowledge, *obscurum per obscurius*—the obscure by the more obscure. Thus there remains a new science or a newly-recognised science, the necessity for which arises the moment we abolish the concep-

tion of a vital force. This science is the chemistry of life, or, as it is commonly called, *biochemistry*. This, of course, is the true organic chemistry; that is to say, if the old term is to be retained at all it should be used not to cover a mere description of the properties of dead starch, on the ground that the starch was produced by a plant, but should be employed to describe the chemistry of organisms.

The Unknown Kingdom of Chemistry. Our making of definitions has now resulted, it is to be hoped, in a clearing of the ground. Henceforward we shall associate the terms *inorganic* and *organic* chemistry with a definite theory which is known as *vitalism*, and which asserted that so-called vital products are the products of life and of that alone. We shall recognise that these terms ceased to have any valid meaning from the year 1828 onwards. We shall further recognise that, if they are to be retained at all, there is abundant scope for their employment. They are so short and convenient that the present writer would be glad to see them reinstated—inorganic chemistry meaning all such chemical processes as are not peculiar to the chemistry of organisms or organic chemistry. Lastly, we realise that biochemistry, or what we should be pleased to call organic chemistry, is as yet almost an unknown land. It has been claimed for science, and the unscientific conception of a vital force has been dismissed from it, but it has not yet been explored, and the would-be explorer is almost without a guide. But it is, of course, incomparably the richest, the most wonderful, and the most important of all the territories to which chemistry asserts her right. If space avail, we may possibly return to this subject.

The Carbon Compounds. As was mentioned in an early section of this course, we now employ the somewhat clumsy phrase "the chemistry of the carbon compounds" to do the work which was formerly done by the term organic chemistry. The substances with which we shall have to deal are compounds of carbon. Carbon seems to be the keystone of their architecture, and it is from the study of carbon that we are best enabled to attack them. This fact is, in itself, of the utmost significance, for carbon is an abundant and widely-spread ingredient of inorganic nature. It is true that a very large part of the carbon upon the earth once formed part of living bodies. The reader already knows that coal represents the carbonaceous part of the bodies of certain kinds of giant ferns which once flourished upon the surface of the earth. But the doctrine that carbon has always been associated with life, or that it is actually a product of some primeval life, or that it is somehow specially inhabited by the vital principle, must accommodate itself to the fact that *the presence of carbon has been abundantly demonstrated in the stars.* The continuity between the organic and the inorganic is thus demonstrated by the facts of this one element.

Marsh Gas. Furthermore, it would be idle to imagine that all the compounds of carbon belong to the realm of what was called organic chemistry, or, in other words, are specially associated with life. On the contrary, on page 1158, we had to discuss the monoxide of carbon, which has the formula CO, and the dioxide of carbon CO_2. No one thinks of these as coming under the head of organic chemistry. The latter is produced by living bodies, but is also produced—and has identical properties when so produced—by the oxidation of inorganic carbon. There is, therefore, absolute and perfect continuity between the two realms of chemistry, as they used to be conceived. This being granted, we may now proceed to the study of a substance which furnishes the key to the structure of a very large number of other substances of greater complexity, and which, though it might quite well have been treated when we were discussing the other inorganic compounds of carbon, was purposely left over so that it might furnish the basis of the discussion which is to follow. This body is the simplest known compound of the two familiar elements carbon and hydrogen, and is commonly known as *marsh gas*, its technical chemical name being *methane*.

The Hydrocarbons. The term hydrocarbon is used to describe the carbides of hydrogen. Let us once and for all distinguish between two terms which resemble one another—*hydrocarbons* and *carbohydrates*. A carbohydrate is a substance which contains, as its name suggests, carbon, hydrogen, and oxygen, the two latter occurring in the proportions in which they are found in water. The two names resemble one another, but have totally different meanings. The hydrocarbons are far more important, since their existence and structure are fundamental in a study of this part of our subject. The carbohydrates have their own importance, as we shall afterwards see, but it is rather practical than theoretical.

The derivatives of the hydrocarbons are endless and, to quote Sir William Ramsay: "May contain oxygen, nitrogen, sulphur, chlorine, bromine, iodine, and many other elements." Let us now return to certain lessons taught us by the typical hydrocarbon.

Lessons from Marsh Gas. Marsh gas or methane has the formula CH_4, as we saw on page 1600. This is itself of great significance. Says Sir William Ramsay: "The fundamental fact on which the chemistry of the carbon compounds rests is, that in them carbon always functions as a tetrad." This means, of course, that the carbon is always "four-handed." We are now past the stage at which it was necessary to accept this fact of valency simply as an inexplicable fact. The new theory of matter, as the reader is already aware, has begun to make it intelligible.

In considering the second lesson of marsh gas we may remind the reader of a previous paragraph, in which it was pointed out that when this body is exposed to the action of chlorine, atoms of the latter gas successively replace atoms of hydrogen, hydrochloric acid being meanwhile formed. We thus get a sequence of bodies,

CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4. Their constitution is thus indicated by graphic formulæ:

$$\begin{array}{ccccc} H & & H & & Cl \\ | & & | & & | \\ H-C-H & & H-C-H & \text{etc. to} & Cl-C-Cl \\ | & & | & & | \\ H & & Cl & & Cl \end{array}$$

These so-called graphic formulæ are a device of the utmost value. They begin to indicate the *structure of the molecule*, and too much importance cannot be attached to this conception in the pages which are to follow.

"Solid-chemistry." The graphic formulæ represented above have, however, an important defect as symbols. The reader will remember that when we were discussing the new theory of matter we described the now famous behaviour of Mayer's needles, but we had to point out that the needles symbolising the electrons of the atom lie all in one plane upon the surface of the water, and thus represent the atom as a flat or two-dimensional object. But, of course, there is every reason to believe that the atom is a solid or three-dimensional object, and we should like, if possible, to have not a flat but a stereoscopic representation of it, showing the relations of its parts in perspective, as one sees in ordinary vision with two eyes or through a stereoscope.

Now, precisely the same defect attaches to the graphic formula of marsh gas as represented above. It suggests that the molecule is a flat object, lying all in one plane. But it would be a great advance to have some means of representing the molecule in perspective and conceiving of it also as not a two-dimensional, but a three-dimensional object. The introduction of this conception has constituted an epoch in chemistry, and the particular branch of the subject which conceives of molecules and studies them as not flat, but solid objects, is now known as *stereo-chemistry*, the meaning of which we can readily remember by recalling the stereoscope (from Greek "stereos," solid). This great advance we largely owe to the famous Dutch chemist Van't Hoff, now professor of chemistry at Berlin.

Substitution. The graphic formulæ above figured illustrate also one of the most important and fruitful ideas in the chemistry of the carbon compounds—and that is the idea of substitution. When, for instance, we compare marsh gas with chloroform we do not simply compare the two empirical formulæ—this being the name applied to the ordinary formulæ—but we compare the two graphic formulæ; and we say that chlorine atoms have been substituted for hydrogen atoms. This theory of substitution we owe to the Frenchman Dumas, friend and rival of Liebig. Liebig at first opposed Dumas' ideas on substitution, but at last he became convinced—says Shenstone in his book on Liebig—"that the character of a chemical substance does not depend so much as he had supposed on the nature of its constituent atoms, and depends very largely also on the manner in which these atoms are arranged. Some years afterwards, at a dinner given by the French chemists to chemical visitors to the Exhibition of 1867, Liebig made his defeat on this occasion the source of a happy retort to Dumas, who had asked him why of late years he had devoted himself exclusively to agricultural chemistry. 'I have withdrawn from organic chemistry,' said Liebig, 'for with the theory of substitution as a foundation, the edifice of chemical science may be built up by workmen; masters are no longer needed.'"

A Small Complexity. It introduces but a small complexity into graphic formulæ to recognise that a certain amount of lack of symmetry may often be met. Indeed, the Dutch chemist whom we have already named has shown that the utmost theoretical importance attaches to the symmetry, or lack of symmetry, of such molecules. Sometimes a single atom having two hands is introduced, and in such a case the molecule becomes somewhat asymmetrical; or, to take the instance of marsh gas again, the four hydrogen atoms may be replaced by two oxygen atoms, giving us a graphic formula like this—$O = C = O$, which of course represents the familiar substance carbon dioxide, and is again symmetrical.

Or we may write the graphic formula of the body CH_2Cl_2 and substitute an atom of oxygen for the two hydrogen atoms that remain. We thus obtain the body carbonyl chloride, the graphic formula of which is:

$$O = C <^{Cl}_{Cl}$$

Carbon Linked with Carbon. Marsh gas does not teach us one of the most remarkable properties of carbon, which goes very far to account for the extraordinary number and complexity of its compounds. This property, other instances of which are very rare, is the power which one carbon atom has of uniting directly with another carbon atom. This we shall come to study when we consider the higher members of the series to which methane belongs, and benzene and its derivatives.

The Properties of Marsh Gas. As we might expect, marsh gas is often produced in marshy ground. It is also very commonly produced in coal mines, thus in both cases having an organic history. It is known to the miner as fire damp, for when mixed with air it forms an easily and extremely explosive mixture. It is a colourless, odourless gas, insoluble in water. The products of its combustion are, of course, carbonic acid and water, and it is hardly necessary to say that it has been liquefied and solidified.

Preparation of Marsh Gas. It is impossible for the chemist to prepare marsh gas by getting carbon and hydrogen to unite directly, except when both elements are in the nascent state. The easiest mode of its preparation is by the action of caustic soda on the acetate of sodium at a considerable temperature. The following is the equation:

$$CH_3CO_2Na + NaOH = CH_4 + Na_2CO_3,$$

sodium carbonate and marsh gas being the products.

Continued

ASIA, AND RUSSIA IN ASIA

Bursting of the Monsoon. Flora, Fauna, Political Divisions, Races and Religions of Asia. Trans-Siberian Railway. Russia on the Pacific. Caucasia and its Oil

Continued from page 2565

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

The Bursting of the Monsoon. Réclus, the great French geographer, has finely described the breaking of the monsoon. "The monsoon is one of the most majestic of terrestrial phenomena. The spectacle presented at its first approach may easily be contemplated from any headland of the Western Ghats, which commands at once a view of the sea, the coast, and the mountain gorges. The first storm-clouds, forerunners of the tempest, usually gather between the 6th and the 18th of June. On one side of the horizon the coppery vapours are piled up like towers, or, to use the local expression, massed like elephants going into battle. As they move slowly towards the land, one half of the firmament becomes densely overcast, while not a speck sullies the deep azure in the opposite direction. On the one hand, mountains and valleys are wrapt in darkness; on the other, the outline of the seaboard stands out with intense sharpness. The surface of the sea and river assumes the metallic hue of steel, and the whole land, with its scattered towns, glitters with a weird glare. As the clouds strike the crags of the Western Ghats the thunder begins to rumble, the whirlwind bursts over the land, the lightnings flash incessantly, the peals grow more frequent and prolonged, and rain is discharged in torrents. Then the black clouds are suddenly rent asunder, the light of day gradually returns, and all Nature is again bathed in the rays of the setting sun."

Heavy downpours occur almost daily while the monsoon lasts, filling the dry river channels, and supplying abundant water for irrigation. The failure of the monsoon means famine and the loss of millions of lives.

Natural Vegetation Zones. These are now familiar. In the north is the tundra, snow-covered and lifeless for more than half the year, but with a brief beauty of flower and berry in summer, when the wandering tribes find abundant pasture for their reindeer, and the flooded rivers swarm with fish. Vast forests, penetrated only by the rivers and the thin ribbon of the Siberian railway, stretch between the tundra and the steppes of Central Asia, which pass into deserts in the rainless regions already spoken of. All these we have seen more or less developed in Europe. What is new is the rich tropical vegetation of the monsoon lands, which reaches its most luxuriant development in the magnificent forests of the Malay archipelago. Stanley's graphic account of similar forests in Central Africa has already been quoted, and the forests of Malaysia are, if possible, still more luxuriantly beautiful.

Animals. It is probable that most of our domesticated animals came originally from the steppes of Asia, which are still the home of immense flocks and herds, often belonging to wandering tribes which follow them from pasture to pasture. The camel is used in the desert lands adjoining the steppes. In the mountains of Central Asia are many wild animals, including the great wild sheep; the yak—an ox—is wild in the high pastures of Tibet, and is used as a beast of burden over the higher passes, some of which are not far short of 20,000 ft. South of the mountain barrier which crosses Asia new animals are found. The buffalo is the draught animal in India and China, and in the former country and Indo-China the elephant is used for heavier work and for show occasions. Snakes and tigers haunt the jungle, the latter animal being found as far north as Korea. The forests of northern Asia are the home of many fur-bearing animals, and the reindeer makes life of a sort possible in parts of the tundra.

Political Divisions. The largest Asiatic Power is Russia, whose dominions—6,394,000 square miles—stretch from the frontier of Europe to the Pacific Ocean. Its southern boundary runs east from the southern end of the Caspian Sea to the Pamir plateau, follows the Tian Shan and other mountains bounding the Mongolian plateau, coincides with the Amur as far as the Usuri, and then runs south along the frontier of Manchuria to the Korean frontier. Conterminous with Russia from the Pamir plateau eastwards is China—4,278,000 square miles—which extends south to the Himalayas and the frontiers of Burma and Indo-China, and west to the Pacific. The eastern part of the Indo-China peninsula is French (256,000 square miles) and the remainder belongs to Siam (200,000 square miles) and Britain. The British dominions—2,000,000 square miles—are India, its eastward extension, Burma, a strip of the south coast of Arabia, Ceylon, the extreme south of the Malay peninsula, Hong-Kong and Wei-hai-wei in China, and part of Borneo. Afghanistan—250,000 square miles—lies between north-west India and south-west Russia. Persia—650,000 square miles—stretches between the Caspian and the Persian Gulf, while Turkey controls Asia Minor, Armenia, Kurdistan, Syria, and most of maritime Arabia—654,000 square miles. The centre and south-east of Arabia are independent. Off the coast of Eastern Asia is the island empire of Japan, including Formosa—160,000 square miles. The Philippines belong to the United States. The rest of the archipelago is Dutch, with the exception of the British possessions mentioned.

Races and Religions. Branches of the white race inhabit the Turkish, Persian, and Afghan lands and much of India. The yellow or Mongolian race is predominant in the Russian Empire, China and Japan. In south-eastern Asia we find the brown or Malay race. Aboriginal peoples, not belonging to any of these, are found in many parts. The great religions of Asia are Mohammedanism, found from the Mediterranean to the Pacific; Buddhism, chiefly among the Mongolians; Hinduism in India; Confucianism in China; Shintoism in Japan; and Christianity among the Europeans, who form the minority in Russia, India, and Indo-China, though they are the dominant race politically. In most parts of Asia two or more religions exist side by side, and no exact limits can be stated for any.

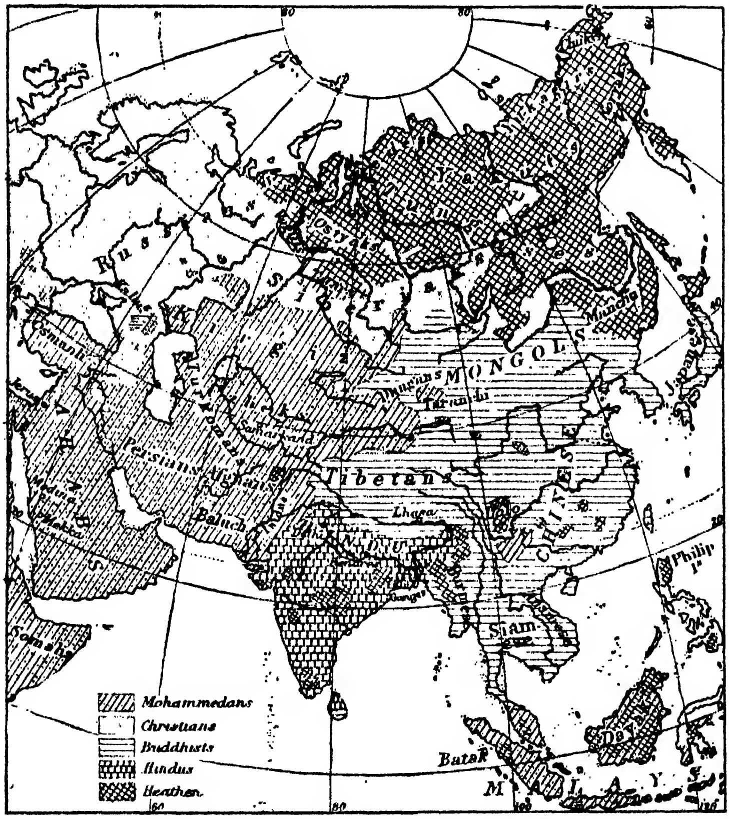
RUSSIA IN ASIA

The ever-growing Empire of Russia in Asia includes the vast region of Siberia, the maritime district of Amuria, bordering the Pacific, Transcaucasia, or the highlands between the Caucasus and the Armenian Highlands, and Transcaspia or Russian Turkestan, the steppe lands east of the Caspian.

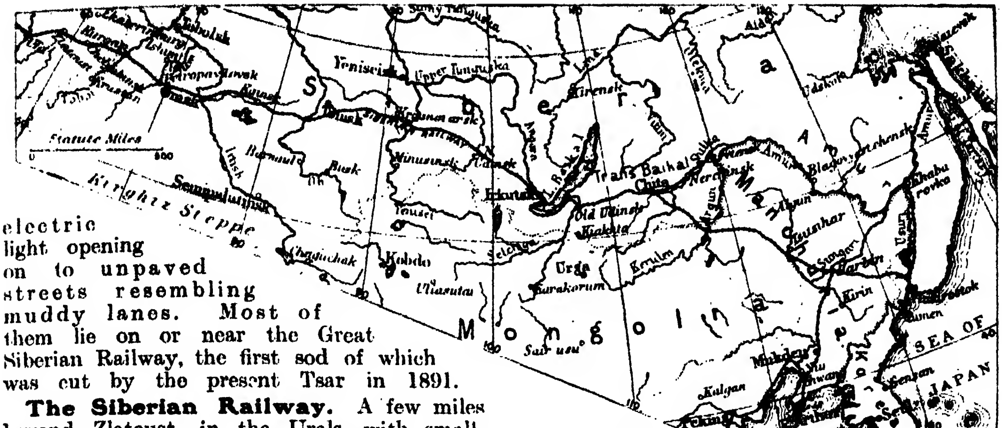
Siberia. Siberia resembles Russia in configuration and climate. It is a vast plain, equal in area to the whole of Europe, rising in the south and east to the highlands of Central Asia. These give rise to great rivers—the Ob, with its tributaries, the Ishim and the Irtish; the Yenisei and the Lena, which flow north across Siberia to the Arctic Ocean. They flow through highland scenery in their upper courses, emerge into the steppes at their northern base, cross the taiga, or primæval forest, and then creep sluggishly across the tundra to the sea, which they enter by great marshy estuaries. All are icebound for months in winter, and great floods occur when the frost breaks up in spring. Navigation is important only during the short summer, and settlement along the rivers is proceeding somewhat slowly.

The climate of Siberia is everywhere extreme, especially in the east, where the northern limit of cereals is nearly 10° further south than in Western Siberia. The summers are hot, especially in the east. In Eastern Siberia barley can be cut two months after sowing.

A Country of Vast Natural Resources. The natural resources of Siberia, though as yet little developed, are very great. The rich black earth of Russia is continued into the steppes of Siberia, which are destined to become one of the great wheat lands of the world. Russian authorities claim that nearly all the land south of 60° N. will be found suitable for cultivation, when the forests are cleared and the marshes are drained. Wheat is grown on the richer, and other cereals on poorer soils. Stockkeeping and dairy farming are extremely important both in the steppes and in the rich meadows. In the forest clearings meat and butter of excellent quality are important exports. At present much of the richest land is too far from markets to be profitably used, but with better means of transport the prosperity of Siberia will increase rapidly. North of the agricultural zone are the forests, rich in fur-bearing animals, and possessing in their timber a source of permanent wealth. Minerals, including gold, are abundant in the highlands, but coal seems to be scarce, and wood is the chief fuel even on the railways. Population is still scanty. Towns are few, though new ones are springing up at central points of communication with a rapidity equalled only in the western United States. All are distinguished by a combination of show and squalor, fine hotels and cafés lighted with



108. THE RACES AND RELIGIONS OF ASIA



electric light opening on to unpaved streets resembling muddy lanes. Most of them lie on or near the Great Siberian Railway, the first sod of which was cut by the present Tsar in 1891.

109. THE SIBERIAN RAILWAY

The Siberian Railway. A few miles beyond Zlatoust, in the Urals, with small-arms factories, the train enters Asia, the spot being marked by a finger-post, pointing west to Europe and east to Asia. Chelyabinsk, the first important station, which has rapidly grown from a small posting station into a large town, is the junction of a line to Ekaterinburg, which joins the line to Perm, for Northern Russia. For nearly a thousand miles the line crosses an almost treeless plain, dotted with occasional birch clumps, and chiefly occupied in cattle-rearing. The stations are some 20 or 30 miles apart, and generally some distance from the town or village from which they take their name. Towards the end of the second day the traveller begins to notice the Kirghiz inhabitants of the steppe, either riding after their flocks and herds, or even taking their seats in the train. They are dressed in long sheepskin coats, with high, red leather boots and fur-trimmed caps, and their bowed legs tell of a life spent in the saddle. The towns of Kurgan on the Tobol, Petropavlovsk on the Ishim, and others are seen in the distance, and at last the train reaches Omsk, on the Irtish, the capital of the steppes. Omsk is in a sense the boundary between east and west.

East of Omsk. From places east of Omsk, wheat, barley, rye, oats, meat, skins, and even dairy produce trend eastwards, to supply the needs of newer settlements; but from Omsk they begin to flow west, to St. Petersburg and Moscow, northward by the rivers to the Arctic ports, southwards to Odessa, and by caravans to Central Asia. The Ob is crossed by a bridge half a mile long, some 60 miles above Tomsk, a university town, which is reached by a branch line. Trees now become more numerous, and soon the train plunges into the forest, through which it runs for hundreds of miles to Krasnoiarsk, on the Yenisei, in the centre of a mining district. The land is now steadily rising to the highlands round Lake Baikal, 42 miles west of which, on the Angara, is Irkutsk, the largest city of Siberia, which is reached on the fourth day after leaving the Ob. It has fine buildings, excellent technical and other schools, and important gold-smelting works. Beyond Lake Baikal the line runs through varied scenery to Chita, the capital of Trans-Baikalia, near which a branch diverges to the Amur Valley. The main line continues south-east into Manchuria, and reaches Harbin, in the centre of a district whose fertility amazes every traveller. "Masses and masses of millet extend mile after mile as far as the eye can see, occasional clumps of trees looking like little green dots in a bronze-brown sea, and the villages themselves being half buried in the surrounding crops." From Harbin the traveller can go east to Vladivostok, or continue his journey south. For two days and nights he steams through crops such as are in all probability to be seen nowhere else in the world, passing Mukden, the capital, and reaching his journey's end on the shores of the Pacific, at the great military and naval base of Port Arthur, which is now held by the victorious Japanese.

The Siberian Line in Winter. In winter all the traveller sees is leagues of snow on every hand, half burying the scattered villages. "Water for the stoves and the train has to be brought hot, lest it should freeze on the way, and men at the stations have to chop off long icicles from the train." This gives some idea of the difficulties Russia has to meet in opening up her Siberian provinces. On the other hand, the intense cold makes it possible in winter to transport meat and dairy produce for long distances without refrigerating cars, which are necessary in summer. Sledge travel is easy over the hard snow, and at Petropavlovsk the traveller just quoted saw the strange sight of sledges drawn by camels setting out for Tashkend in Turkestan.

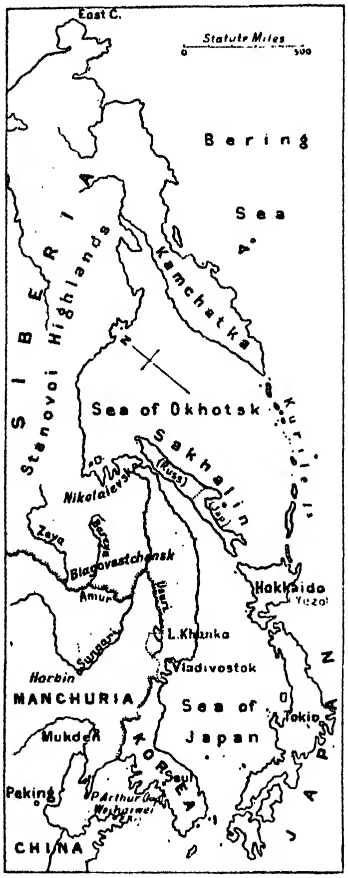
The southern steppes of Siberia on either side of Lake Balkash and in the basin of the Upper Irtish are much hampered by the dry and extreme climate. Sandstorms devastate the country in summer and blizzards in winter. The chief occupation is the rearing of livestock—sheep, horses, cattle, camels, and goats. The largest town is Semipalatinsk, on the Irtish, communicating by that river with Omsk, on the Great Siberian line.

Russia on the Pacific. The Pacific slope of the continent is Russian from Kamchatka to the Korean frontier. The mountainous

peninsula of Kamchatka, with snow-peaks as high as the Swiss Alps, has a dozen active and many extinct volcanoes. The winters are long and cold, the summers short and not warm. A little agriculture is possible in the interior, but hunting fur animals and fishing are the chief occupations. The richest part of Pacific Russia is the basin of the Amur, which separates Russia from China. This river (2,700 miles) gives a route to the Pacific opposite the mountainous island of Sakhâlin, now partly Japanese, while its right bank tributary, the Sungari, has greatly aided Russian designs on Manchuria and a warm-water port, the latter frustrated by the loss of Port Arthur. Blagovestchensk, on the main stream, the administrative centre, has steamer communication with Str tensk in Transbaikalia, Nikolaievsk, the port of the Amur, and Lake Khanka, a feeder of the Usuri, a right bank tributary. The Amur is closed by ice from November to April, as is also Vladivostok, Russia's magnificent harbour and naval station in Southern Amuria. Agriculture in the rich valleys of the Zeya and Bareya, left bank tributaries, gold mining in the Stanovoi highlands, hunting in the great forests, and fishing in river and sea are the occupations of a scanty population living in small villages some 20 miles apart.

Caucasia. Caucasia occupies the isthmus between the Black and Caspian Seas, Batum and Poti being ports on the former, and Baku on the latter. North of the Caucasus, with Elbruz rising to 18,000 ft., are the high steppes of the Terek basin, engaged in agriculture and cattle breeding. South of the Caucasus is the rift, drained west to the Black Sea by the Rion and east to the Caspian by the Kur, with the capital, Tiflis, finely situated in its middle gorge. Both are rich valleys, growing mulberry, vine, maize, and other fruits and cereals. South of these valleys the land rises to the Armenian plateau, which is separated from Persia by the deep valley of the Araxes. The summers are everywhere hot, but severe winters are experienced in the hi hlands. The rainfall is heavy in the west and extreme south-west, but much of the east is arid. The cultivation of cereals, cotton, vine and tobacco are important, with cattle rearing in the higher pastures, but the richest asset is the petroleum region around Baku.

An Oil City. Civil war has temporarily dislocated the oil industry, but soon the following description will again be true. "If there were no oil there would be no Baku. In addition to the Baku of lofty houses, good shops, and spacious streets, there is Black Town, where thousands of tons of crude oil are daily reduced to kerosine, benzine, lubricating oil, and residues for fuel. There are vast forests of derricks, under which are carried on those operations of boring and pumping which disgorge the wealth-bringing oil from the bowels of the earth. Balakhani, with its 2,000 derricks, packed as close as trees in a forest, is one of the weirdest sights I ever beheld."



110. RUSSIA ON THE PACIFIC

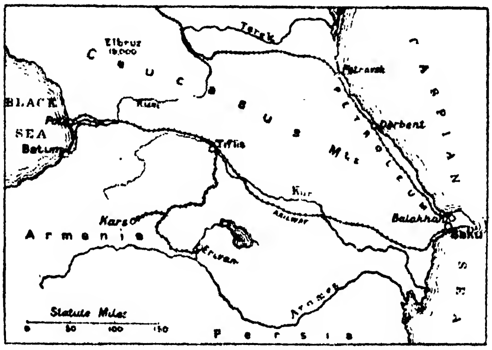
"I stood and watched the rich, dark green fluid, with its pink, glittering froth, being discharged by the great baler of one of the borings, an implement which raises upwards of 100 tons of oil a day. A spouter often blows the derrick to matchwood, but it throws up anything from 7,000 to 10,000 tons of marketable oil, worth from £350,000 to £500,000, in 24 hours."

An Inflammable Region. The soil of this region is so logged with petroleum that inflammable gas is constantly escaping from the surface. It is literally possible to set the Caspian on fire in places, and, by poking a stick into the ground, to set free enough gas to light a flame several feet high. Baku oil goes all over Europe and Asia, and gives Russia a cheap fuel for the Caspian and Black Sea steamers and the railway on either side of the Caspian.

Russian Turkestan. The Russian possessions east of the Caspian and south of Siberia consist of waterless deserts of sand round the Caspian and the Sea of Aral, passing into steppes as the land gradually rises towards the mountains of Central Asia. The region forms an immense basin of inland drainage. The great Amu Daria and Syr Daria flow to the Sea of Aral, while others flow to Lake Balkash and smaller lakes. Where irrigation from any river is possible, an oasis—large or small—can be made, in which cereals, fruits and cotton grow luxuriantly. Russia is devoting great attention to the cultivation of cotton in her Central Asian possessions. It is the staple product of Ferghana, the fertile region at the base of the Tian Shan, watered by the Upper Syr and its feeder, the Naryn. Here are situated the chief towns of Russian Turkestan, linked by the Transcaspian line with each other and with Europe.

The Transcaspian Railway. The traveller starts from Krasnovodsk, on the Caspian, a desert town which distils all its

water from that brackish sea. For many hours the train runs across the desert between low hedges of sand-loving plants, planted to prevent the sand drifting deep over the rails. At long intervals it passes Askabad, near the Persian frontier, and Merv, created by the Murghab, which consequently runs dry before it reaches the Amu or Oxus, both oases in an all-surrounding sea of sand. The Oxus is crossed by a bridge a mile long, and the train plunges across the desert to Bokhara, which owes its fertility to the innumerable canals into which the Zerafshan is diverted. The country gradually becomes less arid towards Samarkand, on the Zerafshan, once, like Bokhara, a world-famous centre of Mohammedan learning, and with some fragments of its former splendour. The line now enters the Ferghana region, watered by the Syr and its tributaries from the south, and passes Andijan, in the centre of the cotton country, Chernayeve, the junction for Tashkend, the chief city of the Upper Syr, Khokand and Marjilan. From Tashkend a line runs across the Khirgiz steppes to Orenburg, where it connects with the European network. A line is projected to the wheat districts of Siberia that Ferghana may obtain cheap food, and devote its rich soil exclusively to growing cotton for the Russian textile industries.



111. THE BAKU OIL REGION

Turkey in Asia. Asiatic Turkey lies west of a line drawn from the eastern end of the Black Sea to the Persian Gulf. Much of the surface consists of highlands with valleys which are fertile under irrigation, but lapse into desert where this is neglected. Of the famous cities of Greek and Scriptural history little remains but the name, and the whole region is in a backward and neglected condition. The great peninsula of Asia Minor, separating the Black Sea from the Levant end of the Mediterranean, is a plateau averaging 3,000 ft. in height, but much higher in the south, where the Taurus Mountains rise to nearly 10,000 ft. The famous pass of the Cilician Gates leads down to the fertile plains of Adana, watered by the Jihun and Seihun, and growing much cotton. The port is Iskanderun, in the angle between Asia Minor and Syria. On the plateau sheep and goats are kept, the wool and hair being made into carpets, and the skins into leather. In the valleys wheat, vines, etc., are grown, and dried raisins and figs are important exports. The ports are Trebizond, Samsun and Sinope, on the Black Sea, and Smyrna on the Mediterranean.

Turkish Armenia. Turkish Armenia lies east of Asia Minor. The capital is Erzerum, a centre of caravan trade, on a fertile plain watered by the Kara Su branch of the Euphrates, which rises in the Armenian Highlands. The elevation makes the winter severe on the pastoral highlands, while in the valleys, where cotton, tobacco, cereals and fruits are grown, the summers are intensely hot.

Mesopotamia. The Euphrates, which, with its tributary the Tigris, drains the Armenian Highlands south to the Persian Gulf, has its upper course in picturesque defiles through the highlands. It then enters the alluvial plains of Mesopotamia, once the garden of the world, and the seat of the famous power of Nineveh and Babylon. The whole of this region has lapsed into a bare waste, with indifferent pasturage, where a scanty population ekes out existence on lands which once fed millions. Bagdad, on the Tigris, once the centre of all commerce between the Mediterranean and the Persian Gulf, has still considerable trade. Excellent dates are grown round the Persian Gulf and exported from Basra. A railway is projected across this region to the Persian Gulf.

Syria and Palestine. West of the Euphrates lies the Syrian desert, continued south by that of Arabia. The Mediterranean littoral of Syria and Palestine receiving winter rains has been, and might again be, extremely fertile, producing all Mediterranean fruits and cereals. East of the Lebanon mountains are Aleppo, on the trade route from the Persian Gulf by the Euphrates towns to Iskanderun, and Damascus, the capital of Syria, and one of the oldest cities in the world, a green spot on the edge of the desert made fertile by the Abana. Haifa and Beirut, in Palestine, are ports on the Mediterranean. Jerusalem, the capital of Palestine, west of the Jordan, which flows to the Dead Sea, is sacred to Christians for its religious associations. A railway follows the pilgrim route from north to south, with branches to Haifa and Beirut, on the Mediterranean. A railway also joins Jerusalem to the port of Jaffa.

Continued

CYCLOPAEDIA OF SHOPKEEPING

FUR MERCHANTS. Prospects for the Practical Man. Beginning Business. Considerations of Fashion. Storing and Jobbing. Finance

GENTLEMEN'S OUTFITTERS. Scope. The Shop and its Fittings. Range of Stock. Outfits for Travellers. Side Lines and Profits

FUR MERCHANTS

The retailing of fur garments is a branch of shopkeeping that must not be lightly undertaken. Furs being more or less a luxury, there is no scope for a general trade, and almost every draper of any pretensions has a so-called fur department. The price of furs of all kinds is increasing annually. Twenty years ago our mothers and our aunts had sable muffs or sable collars for which they paid perhaps two or three guineas apiece ; to-day the same article cannot be bought under ten, or even twenty guineas.

Capital. It will be seen, therefore, that a considerable capital is required before embarking in the business, and, as a matter of fact, it is next to impossible for a man to start a fur store pure and simple unless he has at least £1,500 in hand, and a thoroughly practical experience in all branches of the fur business. Provided, however, he has these requirements and the necessary address and business acumen, he may confidently look for a very comfortable, not to say enviable, livelihood. For it must not be forgotten that although it may be called only an eight-months' trade in each year, during the intervening four months the stock, if carefully packed away, is not deteriorating, but is rather increasing in value, for the steady tendency of upward prices for furs shows no signs of weakening as the years go by. In the summer months there used in years past to be a trade done with American visitors to this country, and especially to the metropolis. But the raising of the American tariff on furs has killed this outlet for the dead season's stock, and the practical man, who is not only a fur seller but a furrier, employs himself in preparing skins, making up stoles, caps, muffs, and so forth in preparation for the next winter's trade. In the summer many furriers now sell, however, feather stoles and feather boas. The ever-growing importance of motoring has given in recent years a fillip to the fur industry. Bearskin coats, caps, and gloves for men, Russian pony coats lined with squirrel lock, and leather-lined musquash trimmed with fox for ladies, are nowadays quite numerous and staple articles in every price list. There are also motor muffs, fur foot-warmers, and rugs that were unknown a few years ago.

Learning the Business. As has already been stated, it is essential, in order that a thorough success may be made of an intricate business, that the prospective fur merchant should be efficiently trained. This training is secured by apprenticeship to a working furrier. The Fur and Skin Trades Section of the London Chamber of Commerce, in conjunction with the Furriers' Association, has a scheme for securing for youths with an ambition towards furriery an adequate knowledge of all branches of the trade. At a meeting of the Fur and Skin Trades Section of the London Chamber of Commerce in 1903 a form of agreement between apprentices and employer was adopted which is now in use. It is an agreement in legal terms on the basis of the usual apprenticeship agreement, arranging for the amount of premium, the term of service (usually five years), the hours of service, and the payment (per week per year) during the period in which the employer would "teach him or cause him to be taught" the art of fur making, fur cleaning, fur dyeing, or what not. The Association endeavours to bring suitable employees and employers into touch, and looks after the interests of both impartially for the general benefit of the craft.

The Practical Man. The advantage which the practical man has over the graduate from drapery, who knows only enough to distinguish kinds and qualities of furs, and to be able to sell them, is all-important, for the chief part of the beginner's work at first will be to carry out repairs on furs that are brought to him, and to make up small garments to order. He should not only know furs, their peculiarities and their characteristics, but he should have a knowledge of dyeing processes, he should be able to clean furs, and he ought to be tailor enough to actually make coats, caps, and other necessary garments. To be ready to give a lady an estimate on the spot for the making of a sealskin jacket or a motor coat is in eight cases out of ten the difference between getting an order and losing it.

Beginning Business. A shop in a good neighbourhood is an essential. It should be carefully decorated, and the rental would be £400 or £500 probably—a modest estimate for a London West End establishment—or something less in the best shopping street of a big provincial city. The fittings should be well made but not elaborate, and in consonance with the expensive character of the stock. One or two solid wall cases with glass fronts and mirrored backs, a counter, and a series of large drawers (for storing necklets, muffs, and linings), a large full-length mirror, a carpeted floor, and a few brass stands with arms for displaying goods are requisite. A sum of £150 to £250 would be spent on fittings of that character—plain, substantial, and good. Mahogany is probably the best wood to select for

the fittings; it will last well, look better, and be more in keeping with the character of the stock than lighter-coloured or more garish material. The best time of the year to start is August, preparatory for the season's trade, which commences in September or October.

The Stock. The fur merchant who knows his business will always be careful not to overstock. The wholesale houses are ever ready to send on approval a varied selection of any particular goods required to suit a customer; but a large stock of any one article or series of articles is not necessary. If a customer is not satisfied with any one of the lines the furrier may have to show, he or she may be satiated on the following day by a further selection which the furrier has meantime obtained from his wholesale house. But it is obligatory that some permanent stock be kept, in order that a show may be made and customers attracted. The furrier would go round several wholesale houses, therefore, and buy about £500 worth for his opening stock. The articles of which he would have the greatest selection would be the easy-selling and less expensive lines in muffs, necklets, stoles, fur linings, fur trimmings, and rugs.

Stoles and ties are more necessary than anything—even than muffs—so a fairly large selection of these should be kept. In muffs he would select one or two of each in bear, opossum, raccoon, natural raccoon, lynx, natural opossum, genet, Persian lamb, grey squirrel, grey astrachan, otter, fox, seal, musquash, skunk, sable, fox, grey and natural moufflon, seal, bear, astrachan, mink, beaver, black Thibet, white Thibet, marten, grey squirrel, sable, chinchilla, ermine, and baum marten. These are for hand muffs; he would require also a few large carriage muffs in opossum (shades), in seal musquash, beaver, astrachan (black and grey), ermine, skunk, chinchilla, black Thibet, white Thibet, sable skin, sable, and beaver. Bag, or flat-shaped muffs in seal musquash, seal, black Persian lamb, beaver, skunk, and mink are still very popular, the round shapes having gone out of fashion. A few children's muffs and ties, chiefly white, in a variety of furs might also be added. The fur linings for cloaks are usually in grey and white squirrel, in all grey squirrel, in kaluga, or in hamster. Fur trimmings (to sell by the yard) include black and brown rabbit, and bear, opossum, raccoon, fox (white, grey, etc.), white hare, natural raccoon, opossum, and lynx, beaver, chinchilla, ermine, grey squirrel, bear, skunk, natural and grey moufflons, white and black Thibet goat, Alaska fox, Celestial fox, black and grey astrachans,* skunk, opossum, mink, seal musquash, natural musquash, otter, squirrel (dyed), stone marten, and sable. As the season advances, lighter trimmings, besides those mentioned, comprise fitch, grebe, kolinski, lamb (white astrachan, krinmer, Persian), marmot, miniver, and nutria. He would also select an assortment of one dozen perambulator fur rugs (mounted on coloured cloth), in white or grey Himalayan goat, grey opossum, jackal, wolf, white Thibet, bear, and wolverine. A selection of fur cuffs and gauntlets might also be made, and half a dozen carriage rugs. The last-named are usually in natural shades of Australian bear, opossum, Himalayan grey goat, jackal, wolf, raccoon, lynx, Japanese fox, wolverine, bear (black, brown, and grizzly), black Himalayan goat, grey fox, red fox, beaver, mink, and sable. It would be necessary also to have one or more sealskin jackets, and an assortment of musquash coats in different styles, with perhaps a sable-coloured coat in squirrel back, caracul, squirrel lock, or Persian lamb, and perhaps a cape or two in sable marmot or electric seal to give variation. Stoles of Arctic fox, sable-dyed marmot, chinchilla, etc., and a good and varied selection of ties in Hudson Bay sable, imitation silver-pointed fox, Alaska fox, Persian lamb, Persian paw, and caracul; mink, stone marten and baum marten are advisable if the money will permit. Then the different styles have to be studied; there is the mink blouse, the caracul jacket trimmed with marten, the caracul sac coat trimmed with embroidered velvet; all the varying tastes and fashions have to be considered.

The Dictates of Fashion. In the foregoing paragraph it must be distinctly borne in mind that an indication only is given of what may be required. It is impossible to state definitely what a man must buy, for the changes of fashion in furs are as erratic and unaccountable as the changes in the weather. This year there may be a run on chinchilla, next year on marmot, the season following on marten, and so on. Sables are about the only fur that may be considered permanently fashionable; but there is not only the fur, but the style of garment to be considered. Jackets of Empire style, loose sacs, boleros, and so forth, may each or all be the rage of the season. Last season there was a run on fur toques and fur hats of various shapes for ladies, and the practice of wearing stoles loosely thrown back over the shoulders necessitated a difference in shapes. White hare was in great demand (also dyed to imitate fox), likewise stone marten and baum marten. The shapes of stoles and ties and their colour vary annually. Squirrel also is most fashionable. The man of experience keeps his eyes wide open, then, on that mysterious female entity—whoever she may be—"who sets the fashion."

Storage and Jobbing. An important part of the business is the storage of customers' own furs during the summer months. Where rich and delicate furs are in question, the responsibility of keeping them is invariably thrown on the furrier, and it pays him to encourage it. Many furriers have special facilities, such as storing chambers kept at the proper temperature—cool, but not too cold. Constant inspection and care must be exercised during the storage period. The furs should be taken out periodically and beaten lightly with a cane beater to free from dust, while a keen watch should be kept on flying scraps of fur, indicative of the probable presence of moth eggs or larvæ. To protect against moths, it is sometimes advisable to use paper, wrapping each article separately, and pasting down so that the casing is as

airtight as possible. The packages are then stored away in a cedar box, or a receptacle containing naphthalene or pepper. In the case of large articles, like coats or capes, it is better to hang each up separately. A coat should always be hung by its own wooden or metal hanger, and this is specially desirable in the case of a heavy fur garment, which is liable to lose its shape if suspended by a neck-loop. A calico or holland bag is used for a coat, made large enough to take the garment without folding, and with a draw-string at the mouth. Camphor should be used with caution, as it is said to possess bleaching properties, but insect powder, coal-tar derivatives, and cedar wood are often employed as moth preventives. Cold storage is the popular method of keeping furs at the present time, but the beginner may not be able to provide a cold storage chamber for some years, and would fall back on the other methods. The usual charge for storage is 1 per cent. per annum on the value of the fur; but West End fur houses charge 1 per cent. per month, and get it without trouble. Besides guaranteeing that the furs are kept free from moths, it is usual also to insure them against fire during the period of storage. The repairing department is important to the beginner. He must be able to undertake alterations in furs, so that sealskin jackets are redyed, relined, and remade in any style. He should likewise be prepared to clean furs and dye them according to the prevailing fashion, besides being ready to dress and mount any skins that may be brought to him. With regard to fur trimmings it would perhaps be better for the practical man to buy skins and cut his trimmings as they are required. At the present time they are not much used.

Buying and Selling. It is not usually worth the fur merchant's while to buy his skins directly in the auction room, but he would keep an eye on the periodic sales, full particulars of which are given in another section—that on DRESS—where also will be found the comparative prices of skins. These prices are, however, for wholesale quantities, and few fur merchants would care to buy regularly in bales. Moreover, the furs have nearly all to be treated before being ready for making up into wearing apparel, and the cost is thus naturally enhanced before the goods leave the wholesaler. But a man of good character and reputation, with a capital of £1,500, would have little difficulty in securing a good reference house and in getting a stock, proceeding, as he would, exactly on the lines described under Drapers. He could buy in August, and have the goods dated November, December, or even later, according to arrangement. It is always well, of course, to pay "prompt," if convenient, as he will thus secure at least 3¾ per cent. discount, and the difference between 3¾ per cent. and 2½ per cent. for two or three months' longer credit is considerable on a large opening order. With regard to profit, it may fairly be considered that an average profit of from 40 per cent. to 50 per cent. on the return must be looked for. At any rate, a gross profit of not less than 33⅓ per cent. must be made in order to tide over the four slack months of the year. Stock should be turned over at least four times a year. When the business is fully established, the experienced merchant will make the end of the season a suitable time to go round and pick up the bargains that may be had, storing them for the summer in anticipation of the rise likely to occur at the beginning of the new season. The trade in cheap furs, such as rabbit and imitation seals, is scarcely worth the candle, so far as the fur merchant pure and simple is concerned. That class of trade is fully covered by the draper, and the profits that accrue would not tend to serious consideration where a £500 rent to be paid out of furs alone is concerned.

GENTLEMEN'S OUTFITTERS

The business of a gentlemen's outfitter is a pleasant and profitable one for a man with method, taste, a popular manner, and the necessary capital. If such a man have served an apprenticeship to the business, and had experience as an assistant for a few years, success ought to follow as a matter of course; but even if the would-be gentlemen's outfitter have no first-hand and intimate acquaintance with this special department, but be familiar with the general drapery trade only, he may be wise in embarking in it. The backbone of a gentlemen's outfitting business is a properly fitting shirt, and the retailer should shape his course accordingly. He should learn to measure for shirts and to cut out from measures. The necessary knowledge can be acquired without difficulty by devoting a good proportion of the spare time of six months.

The most auspicious time for a start is the month of September, when the winter trade—which is the most imporant in the year—is beginning. The capital should not be less than £250, but this will suffice. The shop taken should be double-fronted for choice, with plenty of window space. Display is important. The interior of the shop need not be large. A small shop well stocked is much better than a large one carrying only a thin stock, and as the rent of premises usually depends upon floor space, every square yard saved means lower rent and smaller expense. The site chosen should be near offices or works where men pass frequently. Men do not usually "go shopping" as women do, preferring to make their purchases in the route of their promenade to and from work. The rent of a shop such as we have indicated will probably be about £150 in a city, or half to two-thirds of that sum in a large town.

Front and Window. The exterior of the shop should be painted white or stone colour, and a good glass facia and stall boards should be fitted. If space permits, money should be spent on one or two small outside wall cases, which should always be neatly dressed with the latest novelties marked in plain figures. Such cases, if properly attended to, will be very remunerative. External fittings such as we have indicated will cost about £15. The window enclosure must be made dust-proof, and ought to be fitted with a large side mirror, so as to give

the effect of space. A good variety of window fittings ought to be bought—brass rods with movable brackets, shirt stands, telescopic stands, and a glass shelf, or more than one, along the front of the window. The sum of £15 upon the window interior should not be considered too much.

The Shop Interior. The ceiling should be plain white, the walls neatly distempered, and the floor covered with plain linoleum. These details, with two or three good rugs and half a dozen bentwood chairs, will make a bill of about £10. A similar sum will purchase a 6 ft. or 8 ft. counter, with glass case top, ends, and sides. For the rest, the wall shelving should be of plain deal, of height and depth to suit the stock boxes ; there should be a plain strong table to use for cutting out, and sundry rods and brackets where convenient for hanging goods on for display. It is well to have proper stock boxes of uniform colour. Two or three dozen wood or millboard boxes, covered with green union, will suffice. All these oddments will add another £10 to the expenditure.

Shop Assistance. The expense of shop assistance will not be great at the start. An apprentice engaged for three years may be had for 5s., 7s. 6d., and 10s. per week during the respective years, and in provincial towns the wages are lower still. When an assistant salesman has to be engaged, he will demand £2 per week in the city, if a good man, with probably commission on his sales. The usual commission is 1¼ per cent., and this will make an addition of 15s. per week, on the average, to the assistant's wages

Shirts. In describing the stock, we shall consider shirts first. Those of the best quality should be cut out on the premises and sent out to be made. But the greater part of the shirt stock will be factory-made and bought ready for wear. Cheaper quotations can usually be had by ordering the stock of shirts out of season—have winter requirements made in summer, and vice versâ—as the makers are pleased to fill in slack times.

White shirts with longcloth body and starched cuffs and fronts must be stocked to retail at 2s. 6d., 3s. 6d., and 4s. 6d. each, or at slightly lower prices in half-dozen lots. A business shirt with a short front, narrow wristbands and detachable cuffs, should be kept at about 3s. 9d. Dress shirts for evening wear should have ample wide fronts to suit dress waistcoats, and there is a style with expanding fronts, which is very good. These, of course, should have only one stud hole, in front. Particular attention must be paid to the cut of shirt sleeves so that the cuffs may never cause discomfort when writing. A tape loop at the back of the neck to take the necktie, and a tab at the bottom of the front, are details which, in a shirt, often commend its acceptance. The refitting of white shirts is profitable ; collarbands, cuffs, and fronts for refitting should be stocked.

The pattern of shirt which opens behind is almost obsolete, but a few of them may be necessary in the stock. In cultivating the trade in shirts made to measure, it is exceedingly useful to have, for the use of customers, special forms with diagrams for self-measurement.

A small selection of starched front shirts of French and Manchester prints and cambrics may be necessary. Tunic shirts—with soft fronts—are now much worn, and are made in zephyrs, Ceylon flannels, pure wool flannels, Oxfords, unshrinkables, viyellas, and silk and wool. Then there are shirtings and tropical flannels, tennis, rowing, cricketing, and golfing shirts, with both attached and loose collars, all or most of which must be represented in the stock.

Men's shirts should be kept in sizes from 14½ inches, rising by half inches to 16½. Sizes 15 and 15½ are the heaviest sellers, and should therefore be bought in greater quantity. Boys' sizes are from 12 to 14 inches.

All shirt measures ought to be carefully kept for reference. A good deal of business may be done by mail, especially when customers go to reside abroad, if it be known that this is the practice.

The stock of shirts should absorb about £35 of the capital with which we assumed our outfitter to possess ; about £10 should be spent on longcloth, linen, and interlining, and about £5 on coloured Oxford shirtings and prints. These last ought to be in white grounds with clear stripes and clean distinct patterns. The cuttings from the making of shirts may be sold, one of the minor economies which may be practised in the business.

Collars, Fronts, and Cuffs. About £15 will suffice for a representative stock of those articles. Care must be taken in the shape of collars. Fashion changes and must be studied. As we write, the "Golf Collar," in its various depths, is the vogue. Stand-up collars and a few old favourites must not be entirely omitted, nor must Eton collars for boys.

In making collars to order they should be ¼ in. larger than the neckband of shirt, but in stock collars the size ½ in. larger is near enough.

Neckwear. About £15 may be spent on gentlemen's neckwear, and be distributed over Ascot, and broad-end ties, for sailor's knots, bows and "puffs" to sell at 6d., 1s., 1s. 6d., and 1s. 11d., tubular ties for summer wear, made-up bows and fill-up scarves, dress ties and bows. Judgment must be exercised in purchasing this stock. In both colour and shape of neckties the public are particular, and to become loaded with stock that does not meet popular approval is a serious business. There is moderate scope for enterprise in pushing ties and scarves made to order.

Under the same class may be included mufflers in cashmere, in silk and wool, and in all silk.

Handkerchiefs. This department may be stocked adequately by an expenditure of a £10 note. It will embrace coloured cotton handkerchiefs, and all-white linen handkerchiefs with woven borders in three-quarter and seven-eighths sizes, cambric handkerchiefs with

coloured borders and spots in three-quarter size, and silk handkerchiefs—white, crimson, and mixed colours—to sell at 2s. 6d. and 3s. 6d. each. Years ago when the habit of snuffing was not considered bad form, it was an ordinary thing to sell yard-square thick twill-silk handkerchiefs at 9s. 6d. each. They were often sold in pieces—seven handkerchiefs in a piece—and one customer might buy two pieces. But these days have fled.

Hosiery and Gloves. These classes of outfitters' goods will demand an expenditure of £25. They will include cycling, rowing, and athletic hose, jerseys and sweaters, in addition to ordinary workaday hose and gloves. Detailed particulars of these departments are given in the article "Glovers and Hosiers" in this course.

Sundries. One of the principal articles in the group we describe as "sundries" is braces. The shilling article is the favourite one, and a good, strong, serviceable brace must be sold at 1s. a pair. The French narrow-web brace with elastic ends should be kept. Also strong English-made articles to sell at 1s. 6d. and 2s. 6d., also a few pairs of buckskin braces, with a few body belts and leather belts, will require about £5 expenditure.

Then nightshirts, pyjamas, fancy waistcoats, dressing-gowns, and smoking-jackets constitute a small department in which the individual articles are more expensive and will leave nothing out of £20 if a representative selection is to be shown.

Studs and sleeve links are remunerative articles, and take up little room. The stock should be shown in the counter case. The sum of about £5 will purchase a good selection. The more expensive varieties may usually be had on sale or return.

Outfits for Foreign Travellers. Some districts are favourably situated for pushing trade in outfits for hot and cold climates. When the shop of the gentlemen's outfitter is so situated its proprietor should not fail to take advantage of his opportunities. This department should be encouraged by the publication of a printed list showing details of a wide range of goods suitable for foreign countries with climates different from our own. That everything shown in the list is not kept in stock matters little. Special articles can always be got without delay, and the man about to go abroad does not require his outfit at five minutes' notice. He prefers to give his whole order at one place. The usual stock to appeal to this sort of traveller is as follows:

Day shirts—tunic, with loose collars.
,, woollen, with collars attached.
Collars, gloves, ties, and scarves. Handkerchiefs, undervests and pants, and "united undergarments."
Socks and stockings, for shooting, cycling, etc.
Pyjamas and nightshirts.
Knitted waistcoats and under waistcoats, for wearing under tunics.
Cuffs and studs.
Colic belts, body belts, leather belts, money belts.
Braces, gaiters, putties.
Sleeping bags, woollen sheets, camelhair blankets, sweaters.
Hair, hat and clothes brushes, combs, razors.
Soft felt hats, knitted travelling and sleeping caps.
Flannel suits, overcoats, rugs.
Lounge jackets, Cardigan jackets.
"Housifs"—containing needles, pins, buttons, thread, scissors, and a thimble.
Bags and trunks [see special article].

Sales and Side Lines. It is always well to have a "sale" between seasons, as the practice clears off odds and ends that tend to accumulate. Job goods can always be had from manufacturers and sold at low prices, but still at fair profits.

There are many side lines which can be associated with the business of a gentlemen's outfitter. Such things as trousers stretchers, umbrellas and walking sticks, and leather goods always go well with the class of customers to whom the outfitter appeals. The Christmas trade in presents offers opportunities which should not be neglected. A haircutting and shaving department is usually remunerative apart from the direct profits, especially if to reach the hairdressing saloon customers have to walk through the outfitting shop.

Profits. The profits on the selling of gentlemen's outfitting goods should be 25 per cent. of retail prices, which equals 33⅓ per cent. of cost prices. Naturally, articles of everyday sale are often sold more cheaply than other articles which move more slowly, but this is balanced by the larger profits in some departments.

In London arrangements can usually be made with one of the large carrier companies to deliver parcels in London and its suburbs at a uniform charge of 3d. each.

At the initiation of the venture the new starter may be a little pressed for money. The terms of accommodation that he may obtain will depend upon himself. If he be known to the manufacturers and wholesale merchants as a good salesman and to have the qualities that go to make success, he will be generously treated. The usual terms of wholesale trading are monthly accounts with 2½ per cent. discount. Bills may have to be accepted if, as is probable, it be found that more capital than was anticipated is being locked up in stock, but with judicious economy the man should find after three years' trading that he is free from accumulated obligation and can meet all his bills promptly on date.

He can thereafter take advantage of any special discounts offering for prompt payments and begin to keep his eyes open for cash bargains which are beyond the reach of the trader without available ready cash.

Continued

THE VEHICLE DRAWING OFFICE

Dimensions, Draught, and Suspension. Full-size and Scale Drawings. The Cant Board. How the Different Trades Utilise Drawing

continued from

By H. J. BUTLER

THE sizes of vehicles are important points of consideration for the draughtsman. The leading proportions, such as are subservient to the presence of the passenger and his easy ingress and egress, have been dealt with in the previous chapter.

The over-all dimensions of the different types are illustrated in **2** to **18** [page 2463], and it will be interesting to note how they compare with one another. Railway stock is certainly overwhelming when seen drawn to the same scale as a van or brougham; and the absence of the horse in the motor-car greatly shortens the over-all working length when compared with the animal-drawn type. Of course, fire-escapes do not run about in the streets fully extended as the one shown.

The sizes of the various pieces of timber used in construction have to be known by the body or pattern-maker, or whoever has the marking-out of the stuff. It would be a huge undertaking to tabulate all the various members used in the thousand and one different bodies running on wheels. Different workmen have their own particular fancy as to the size of a pillar or rail, but in any case a medium framework judiciously strengthened by ironwork is to be sought.

Compensation for Weakness. If a pillar have several mortices or laps taken out of it, or, perhaps, be made to take a lock or hinge, we must add to its strength to compensate for the presence of these sources of weakness. The corner pillar of a brougham is made light, having little work to do, but its adjacent member, the short bottom side, has to withstand the fixing and strain of the pump-handle. We should expect to see different dimensions in the felloe of a two-wheeled rustic cart and in the hind wheels of a pantechnicon. In short, we must consider the work the piece has to do and what is fixed to it. Sometimes the shape or design of the body decides the dimensions. The reader is referred to the accompanying tables, which give leading dimensions of various types.

Draught. The draught of vehicles is a subject which has had much theory expended on it, and in such complex instances as road carriages with locking fore-carriages and weight distributed in various positions between the wheels, no doubt the constructor has built on the safe side, being unable to work out his stresses satisfactorily. In railway work it has been more or less reduced to a science. On the permanent way we have very little friction between tyre and road, it being well known that there is often the difficulty of an insufficient amount of attrition. The force of gravity, or dead weight of the vehicle, combined with the various gradients is the chief resistance to be overcome. The axle-arm or journal and the inner surface of its encasing box is also a factor in summing up the various sources of friction set up. In like manner the speed of the train means a proportional increase of energy to be expended by the tractive force.

Influencing Factors. On our highways we have different road surfaces, kept in various states of repair and under varying changes of weather. Apart from the actual surface there are always accidental matters such as loose stones and ruts to take into account. The friction between the case-hardened exterior of the axle-arm and the similar finished interior of the box is not a very great factor in draught, as in all types of vehicles we see great perfection attained both in the construction of the adjacent parts and in the allowances for efficient lubrication.

The best point of draught in a two-wheeled horse vehicle is a line from the animal's shoulder to the axle. In four-wheelers it has been found that a line midway between the two axles and the point before mentioned gives the best result. If the weight be well supported in the wheels, we have an easy running vehicle. A four-wheeled dog-cart is easier to pull than a sociable for that reason. The narrower the track of wheels and the less the wheel base, the easier under ordinary circumstances will the carriage run.

Suspension. *Suspension* is the consideration of the various mediums that exist between the body and the wheels and axles. The different kinds of springs are designed to minimise the shocks to which the body is subjected by the contact of the wheels with the road where the roughness of the ground would soon break any type of spring. Springs are not fixed in such vehicles as general service waggons of the Army, although the driver has a spring under his seat to give a little comfort.

Types of Springs. The coachbuilder uses the elliptic spring, which has the load either exactly above or below the support, the side spring, with load at both ends and support in the middle, and the elbow spring, which has the load at one and the support at the other end. From these may be subdivided many other forms.

The C spring, an old type, and really an elbow spring, has to withstand the forward pull of the brace. Combined with a dumb and under spring and perch under-carriage we see an old-fashioned, costly, yet unequalled, riding undergear. Much depends, however, on the braces. Van builders use heavy elliptic springs, especially in fore-carriages, but the greater part of the suspension is effected on side springs of strength varying with the load with or without cross and check springs.

The motor car manufacturer uses side springs, sometimes in conjunction with cross springs, but with the presence of the pneumatic tyre, which is in itself elastic, the attention given to suspension is not perhaps as great as it should be.

The railway coach and waggon builder uses springs of similar type to the heavy van builder. In bogies used under train and tram there are various special elliptical, side, and spiral or helical springs used. Springs are illustrated further on.

of sufficient accuracy for an experienced workman. When our coachmakers have made a drawing—probably just an outline elevation with a few cross measurements—they can make it suit their purposes for the construction of many succeeding jobs. The Frenchman generally makes a new drawing for each body undertaken with the result that his designs are fresher and please the critical eye of his customers, especially of those who demand novel outlines.

The French motor-car builder is a successful rival to us in the designing of motor-car bodies, simply because he pays more attention to it.

CARRIAGES AND PUBLIC SERVICE CARS.

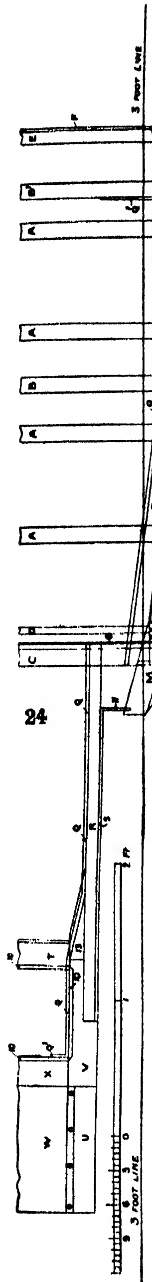
Type.	On Elbow.	On Seat Rail.	Tare Weight.	Wheels.
Double brougham ..	4 ft. 6 in.—5 ft.	3 ft. 3 in.—3 ft. 9 in.	9—13 cwt.	3 ft. and 3 ft. 8 in.
Canoe or square landau (one horse)	5 ft.—5 ft. 6 in.	3 ft. 3 in.—3 ft. 6 in.	9—13 cwt.	3 ft. and 3 ft. 8 in.
Full-dress coach	6 ft. 8 in.	3 ft. 10 in.—4 ft.	18—21 cwt.	3 ft. 4 in. and 4 ft. 2 in.
Four-in-hand coach ..	4 ft. 8 in.—5 ft. 2 in.	3 ft. 3 in.—3 ft. 6 in.	18—24 cwt.	3 ft. 2 in. and 4 ft. 2 in.
Two-wheelers	Length of body, 20 in.—24 in. for one seat, 34 in. to 38 in. for two seats; depth of body according to design	Width as above vehicles and according to style	3—7 cwt.	3 ft. 6 in.—5 ft. 2 in.
Mail phaeton	Average, 5 ft.—5 ft. 3 in. on seat line	3 ft. 6 in.—3 ft. 10 in. head room	8—10 cwt.	3 ft. 3 in. and 4 ft.
Four-wheel dog-cart ..	3 ft. 6 in.—4 ft. 2 in. length of body on seat line	3 ft. 3 in. average on seat board	5—7 cwt.	2 ft. 9 in.—3 ft. 2 in.; 3 ft. 6 in.—3 ft. 10 in.
Victoria phaeton.. ..	From boot, 5 ft.	3 ft. 3 in.—3 ft. 8 in. on seat	6—8 cwt.	3 ft. and 3 ft. 8 in.
Tramcars (double-deck; electric; 80 passengers)	23 ft. 6 in. on seat line over all	7 ft. wide overall across body	5 tons body only	20 in. and 30 in.
Omnibuses (horse-drawn; garden-seat)	9 ft.; 12 passengers inside and 14 outside	5 ft. 10 in. over body; 6 ft. 10 in. over roof	33 cwt.	3 ft. 4 in. and 4 ft. 6 in.

VANS.

Type.	Over-all Dimensions. L = length; W = width; H = height.	Wheels.	To Carry a Load of—
Small covered motor van body..	L, 5 ft. 6 in.; W, 4 ft. 5 in. at top; W, 2 ft. 7 in. at well; H, 4 ft. 10 in.	800 mm.	10 cwt.
Open parcel van..	L, 8 ft. 6 in.; W, 4 ft. 3 in.; H of sides, 2 ft. 1 in.	2 ft. 10 in. and 4 ft. 4 in.	30 cwt.
Market gardener's or forage van	L, 8 ft. 4 in.; W. 4 ft. 2 in.; front ladder projects 2 ft. 7 in.; hind, 3 ft.	3 ft. and 3 ft. 6 in.	2 tons
Box van	L, 5 ft. 8 in.; W, 3 ft. 11 in.; H, 4 ft. 8 in.	2 ft. 10 in.—4 ft.	15 cwt.
Timber trolley	L, 11 ft. 6 in.; W, 4 ft. 7½ in.	3 ft.—4 ft. 6 in.	4 tons
Horse ambulance (two-wheeled)	L, 8 ft.; W in centre, 3 ft. 6 in.; H, 5 ft.	5 ft.	1 ton
Baker's van	L, 4 ft. 9 in.; W, 3 ft. 6 in.	2 ft. 7 in.—3 ft. 8 in.	10 cwt.
Pantechnicon van	L, 16 ft.; W, 7 ft.; H, including well, 6 ft. 8 in.	2 ft. 9 in.—4 ft. 3 in.	3 tons

Drawing. Engineering has always been associated with carefully-prepared drawings, and, to be efficient, the mechanical draughtsman must work with great precision and neatness. We are not, therefore, surprised to find that where the greatest attention has been given to vehicular drawing is where engineering plays an important part. The drawing office of the railway company and motor-car builder contains many skilled workmen. Among carriage builders it is exceptional to find an expert draughtsman on the premises, as a clerk, or maybe the foreman, is capable of turning his hand to a full-size or scale drawing

Geometrical Design. When body drawings are prepared in the engineering office by an engineer, one may see in his designs many traces of the principles applied to engines—that is, straight lines rounded off at the ends with arcs of circles. In railway carriage work all curves are usually described as being of certain radius, the rise in the roof being an example. We see this in some bodies of motor-cars, for which type of carriage it gives a very hard appearance. In railway work there is no objection to this business-like exterior and



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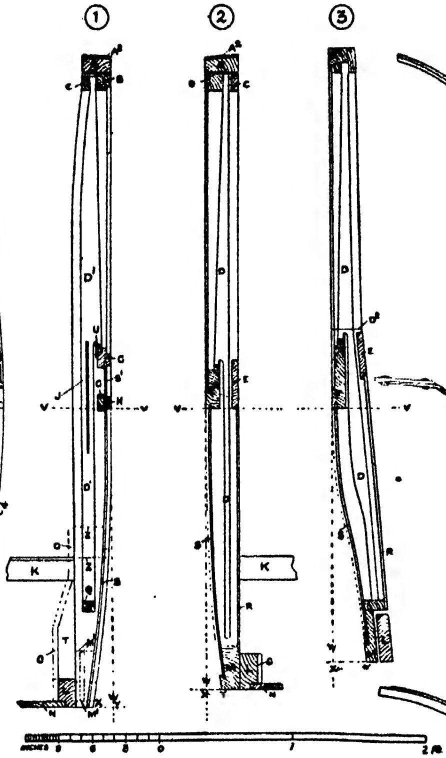

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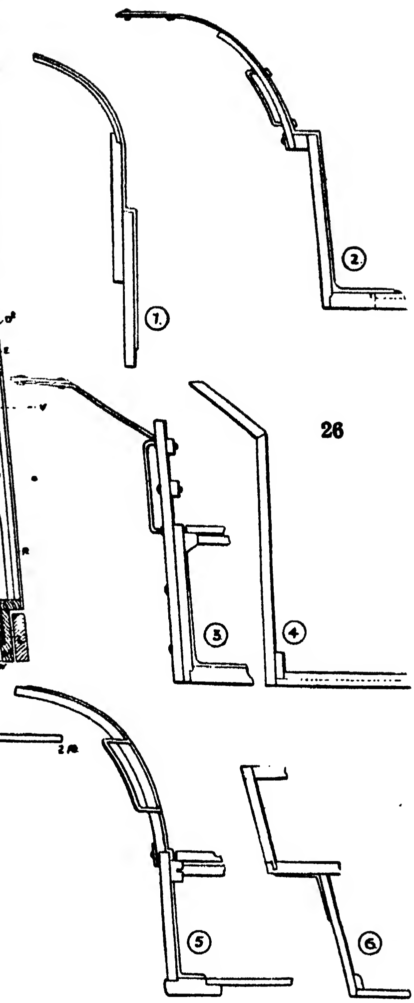

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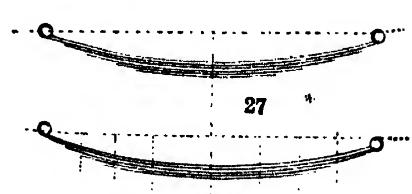

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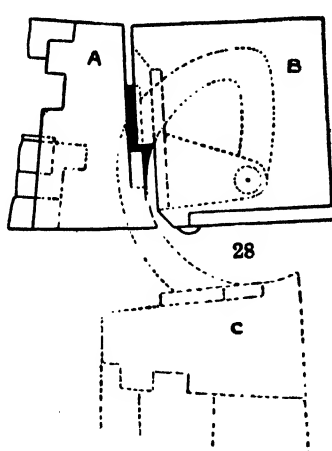

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CONSTRUCTIONAL DETAILS OF VEHICLES

24. Detailed cant board of a single brougham A. Hoopsticks B. Front seat rail B1. Hind seat rail C. Front fence rail D. Front garnish rail E. Hind top rail F. Top back panel G. Quarter panel H. Corner pillar J. Hind standing pillar K. Hinge door pillar L. Shut door pillar M. Front standing pillar N. Fence, door, or middle rail O. Door bottom P. Rocker Q. Edge plate Q1. Edge plate flaps R. Solid boot side S. Boot side panel T. Bottom boot bar U-V. Bracket and boot bottom side W. Footboard X. Bracket bar Y. Short, or seat bottom side Z. Standing pillar plate (let in flush) 2. Panel to hide above 3. Glass run in front fence rail 4. Side sweep line 5. Turnunder line 6. Fence plates 7. Inside line of cant rail 8. Outside line of short bottom side 9 Hinge centre 10. Rabet for floor board 11. Contracting panel 12. Clear between rocker and door bottom 13. Wedge piece **25.** No. 1. Combined section of door and standing pillar, double run No. 2. Combined section of door and standing pillar, single run No. 3. Door pillar and pillar top section of a landau A. Cant rail A1. Cant rail and door top combined A2. Roof board B. Door top C. Top garnish rail D. Single glass run D1. Double glass run D2. Cut between door pillar and pillar top E. Garnish rail F. Solid fence rail G. Top and bottom fence rail H. Elbow moulding (pinned on) J. Guide separating wash blind from glass frame run K. Seat rail (fixed to standing pillar) L. Rocker (fixed to standing pillar) M. Door bottom M1. Position of door bottom and check into pillar N. Floor board O. Edge plate P. Glass frame rest Q. Rubber buffer for glass frame R. Lining board S. Door panel S. Fence rail panel T. Wedge piece U. Fence plate V-V. Elbow line W. Square line of pillar X-Y. Turnunder Z. Position of short bottom side **26.** Six different methods of side framing in 2-wheeled carts No. 1. Method giving a recess between seat line and bottom side No. 2. Typical bent side in conjunction with straight body side No. 3. Rustic cart, showing position of seats No. 4. Cheap method; bottom not framed No. 5. Bent side forming wing, similar to No. 2. No. 6. Governess car **27.** Method of drawing the plates of a spring: first, centre line through eyes, allow for pitch, mark compass on centre line; bottom line of long plate runs to bottom of eye; all lines parallel; cut off lengths of plate and finish with a sharper curve **28.** Detail of door and standing pillar showing working of concealed hinge A. Door pillar B. Standing pillar C. Door pillar in open position

general distribution of the parts. We naturally expect to see fancy sweeps of any description finding little favour. Being on a proper strengthened underframe, it follows that the standing, side and corner pillars can be set out with mechanical exactness. If side doors are not included, the designer is able to apply still longer, never diverging straight lines. Strap plates, corner plates, commode handles, the position of bolts, are all set out as if some thinking machine rather than a human agency had been at work. Still all this is fitting for its particular purpose.

Artistic Treatment. In motor-car work, by all means let the engineer have hard and fast lines for his frame, engine, and transmission gear, but the body demands a little more artistic license in its preparation. At the present state of automobile coachwork there is to be seen much freehand treatment in the contour of the several bodies. The Roi des Belges type of tonneau requires much skill in its delineation both from the draughtsman and from the patternmaker.

It is remarkable that such a harmonious combination of curves as in a C-spring victoria could have been evolved from a branch of industry where so little attention is paid to drawing. Among certain shops undeniable evidences are seen of the want of proper preparation before marking out the stuff. A notable difference in broughams is seen between, say, a Barker-shaped carriage and the usual "growler." It is very little excuse that because the latter is a cheaper vehicle, the material should therefore be badly shaped. A simple outline to work to takes little time to prepare, and where duplication can be carried out without disadvantage, as in a stage carriage, the first drawing suffices for a number of bodies.

Need for Working Drawings. The average van builder will probably resent the suggestion that there are advantages in a working drawing. He will argue that his business has been conducted with success for many years without drawings, and therefore why should he burden himself with a needless array of paper and pencil or blackboard and chalk. With a few sizes noted on the back of a piece of glass-paper or waste timber he will gladly set to work to erect his van or cart. Still, perhaps, the day is not far distant when, with drawings of the useful scale of 1½ in. to the foot and a few to full size, we shall see him who uses them judiciously outrunning his fellow tradesman who starts straight away with his saw and plane.

The Study of Drawing. It is perhaps a promising outlook for those who have a deep concern for technical education that drawing plays a conspicuous part in the code of our schools. By its means the rising generation has the opportunty of being grounded in the elements of a subject which plays an important part in the success of those who enter the constructional trades.

After simple balanced freehand copies have given place to those more difficult, any child with a gift for drawing will have laid the foundation for much useful work. Freehand, a term used in the best sense of the word, that allows the wrist full play and gives on the paper lines that *flow* from the pencil, and do not consist merely in a series of spasmodic sketching jerks, cannot be given too much attention, and many of the leading coachbuilders lay great stress on the practice of this branch of work.

A designer will never create much that is beautiful if he tie himself to the use of a scale, rule, compasses, and ready-made curves. Let him display his thoughts on paper, entirely unfettered by mechanical means, and, given due allowance for the construction of the vehicle in hand, he will be all the more likely to produce a pleasing result. Freehand, therefore, is the basis and true root of all real design.

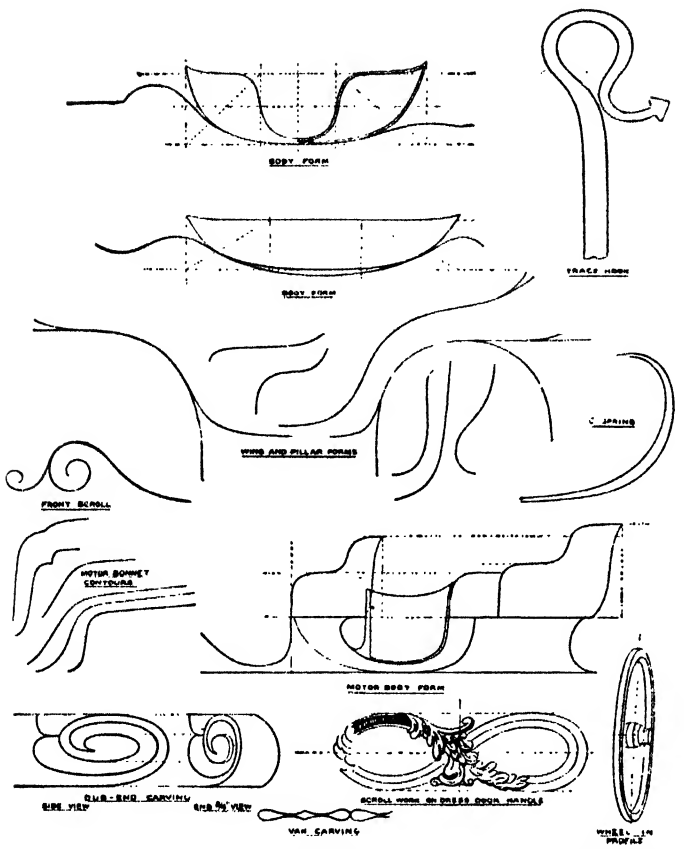
Scale Drawings. Then one may turn to the mechanical side of drawing. Scale drawing, the portrayal of an object to a certain definite generally reduced proportion, is a very useful means of outlining the first rough work of a new job; and in railway work the finished drawing cannot be conveniently made to full size except in sections. Although many scales are used, 1½ in. to the foot, or one-eighth full size, is handy on account of the body-maker's rule being divided into eighths of an inch, every such division representing an inch on the small drawing. This work requires care in using the scale rule, although so-called scale drawings are not always drawn accurately, but only approximately in proportion, the situation being saved by writing the real measurements adjacent to the various lines. Probably a piece of work so finished is more quickly done, but is apt to be misleading and cause mistakes if a more correct drawing is not forthcoming for actual use at the bench.

Perhaps the railway carriage draughtsman turns out some of the finest scale drawing seen in vehicular work. Those who have seen a finished side elevation, plan, longitudinal and transverse section, together with a drawing of the frame and chief details of the running gear, will appreciate the remark.

Projection. Scale drawing must be accompanied with a knowledge of how to project the different views in order to help form another. Plane and solid geometry has then to be studied carefully. How to draw an arc through a given point, to divide a line or arc into a number of given parts, to construct or copy an angle, are only a few simple instances among the many items that crop up in following this occupation.

In more complex bodies, as carriages and motor-cars, the turnunder and side sweep, scale of body-side and wheels, the outline of the body generally, all tend to make a back elevation or plan at first difficult to mark out correctly.

Model drawing is useful in giving the ability to make a rough sketch from the actual object, which is a convenient way of taking measurements. To be properly done, a wheel in half profile, a compassed bed, or the conformation of a finished piece of trimming, requires a study of object drawing.



29. FREEHAND OUTLINE, SUITABLE FOR TRAINING VEHICULAR DRAUGHTSMEN

Manipulation of the Tools. However much one may be versed in the theories of the work, the success of the drawing depends in great measure on the actual manipulation of the tools. Considerable accuracy is required in vehicle drawing. One should have a sharp chisel-pointed pencil of suitable hardness, measurements must be taken carefully from the scale with the eye directly over the division line on the rule when taking a dimension, and a series of measurements must be checked by an over-all one. It is important that the drawing-board and T-square have true edges, and that right angles are formed the one with the other. A T-square with a long blade requires careful handling, and the paper or tracing-cloth should be stretched evenly and tightly over the board. Stretching paper by wetting and gumming the edges produces an unsurpassed surface on which to work.

The drawing pins, when used, should be inserted leaning inwards towards the centre of the paper, and drawn over while being pushed home, so as to pull the paper tight.

Drawing Pencils. Most draughtsmen prefer a hard pencil, such as H. or H.H., but it depends on the delicacy with which the tool is held. Some who have had a previous experience in working hard woods, such as ash or teak, give to their pencil some of the old effort more suited to the chisel and router. In skilful hands, an H.B. pencil of good quality should answer an all-round purpose, but consideration must be made for the cleaner working of a hard lead. The use of compasses requires dexterous fingers, especially spring bows. Painstaking draughtsmen often draw with these little compasses the heads of bolts, spring eyes, the links of driving-chains and caps, and little corners are rounded off with them.

Indian ink, either in bottle or rubbed up on the saucer, is used to line in the drawing. A stick of good quality, rubbed upon a vellum-surfaced saucer, on which a little water has been placed—the pen being filled with a brush—will produce better lines than dipping the pen into a bottle. Fixed or waterproof ink is difficult to work, having a tendency to clog. Whatever method be adopted, the sides of the pen should be wiped before use.

Indiarubber is a useful adjunct, and the variety that least destroys the surface of the paper is the best. Ink-eraser that does not depend on powdered glass or other scratchy substances for the proper fulfilment of its purpose removes ink lines and paint. The penknife should never be used.

Tinting. The mention of paint brings up the subject of tinting. This is, perhaps, more adopted in show work for exhibition or for examination purposes. It is useful for a student to tint the various parts in accordance with the material used. By this means a working drawing becomes an artistic as well as a helpful chart of study. Tracings are often tinted on the back of the work. Fixed ink is useful for lining in the work before tinting.

The draughtsman may complete his studies by taking up perspective, which, in a simple form adapted to commercial requirements, will be useful, as may be seen in architectural work.

Value of Coloured Drawings. In the carriage and motor trades, where vehicles are made to sell, it is often an advantage in getting an order or clinching an inquiry if a coloured drawing be neatly made and despatched promptly to the customer. Should the style required be something new and the would-be purchaser require some special ideas of his own

carried out, then the draughtsman has an opportunity of showing his real worth. An outline side-elevation drawing, perhaps in pencil, is "good enough," some will say, but a rival firm may make a small coloured perspective drawing on a gilt-edged card, and send it to a customer, who may chance to be a lady. Comparison is then made between a stern business 1½-in. scale H. pencil working drawing and a ½-in. scale coloured little picture, showing a glance of the interior trimming. Perhaps the draughtsman may be forgiven if he has taken some license in making the body a little lower on the ground, and the door an inch wider in the opening. If a motor-car be the object under consideration, and the prospective purchaser is undecided and hesitates, being a lover of horses, then the artist shows his tact by making the mechanical portions as inconspicuous as is practicable.

The Sphere of the Brush. The use of the brush is at its highest when it is used for touching up the junction of lines, rounding off dub ends, and other work too microscopic for the compass.

The road-carriage builder's draughtsman will find that the usual shop French curves do not serve his purpose to any extent for scale work, and he will do well to buy veneers of boxwood or beech, and cut them out on the fretsaw to those shapes that he will soon discover are most useful. The railway draughtsman has little or no curves to worry about.

In the van trade little is done in supplying inquirers with special drawings, but one may see that, with the different colour schemes and writing displayed, a wide field is open for work in this direction. A certain well-known firm of caterers advertise themselves to an appreciable extent by the presence in the streets of vans and carts that are two shades of blue, with writing and lining in white, blue, and gold. While considering this artistic branch of the work, perhaps a word or two may be said as to catalogues.

Catalogues. Railway people generally place their productions before the camera, and leave the result to the devices of the process-engraver. Many excellently-printed catalogues, illustrated with half-tone blocks, emanate from the various companies that supply rolling stock. Automobile makers do the same, likewise van-builders, and the trade of the latter being older than that of the former, a good display of wood-engravings are to be seen. American carriage catalogues are also seen well illustrated in this manner. The carriage builder finds that the playful distortions of the camera and the reflections in highly varnished panels do not flatter his work, especially when criticised by a non-photographer. But the work may be much improved by retouching, and vehicle photography is a branch that calls for as much judgment on the part of the operator as architectural work.

Catalogue Illustration. To illustrate a circular, be it large or small, with photography as the first process necessitates the actual existence of vehicles. But a coachbuilder, especially if he caters to the motor-body trade, can keep his designs up to date and indicate future novelties without having recourse to a considerable outlay of capital by having drawings as a basis.

In advertising with illustrations it is well to remember that the mesh of the block must be comparatively coarse if it is to be used in an ordinary newspaper, while the finer the surface given to the glazed art paper the finer may be the screen used. Line work and line blocks are cheaper means of producing illustrations. The printing can be done on a common paper, and this medium is suitable where much expense is not justified.

Full-size Drawings. Full-size drawings are used chiefly by the road carriage builder. Paper may be obtained up to 74 in. wide and of almost any length. It is desirable to make such drawings on paper for future reference rather than on a blackboard, although opinions differ.

A plumb line makes a starting line from which the horizontal lines may be taken. A large square board is allowable when a long straight edge can be nailed along the bottom of the work. There are occasions when it is better to construct a right angle geometrically rather than by square. A moulding may be made parallel by the skilful use of a pair of quadrant compasses having a retaining screw, which are then set to gauge and run along the edge of the pattern. The draughtsman should remember that upon the accuracy of his work depends the success of the ultimate patterns or templates, and consequently the finished article.

A section of the door and standing pillar combined, showing the glass run either single or double, together with the position of the cant rail, door top, fence rail, elbow, short bottom side, door bottom, and rocker, and the fixing of the edge plate, is an example calling forth much careful work. The designer must remember that increase of turnunder means heavier and more expensive material, that the glass-frame when up must be safely retained on the fence rail, and be sufficiently recessed in the groove in the door top. Again, when released, it must have a corresponding depth below in the door, so that in carriage work of the best description the top of the frame is level with the top of the fence plate.

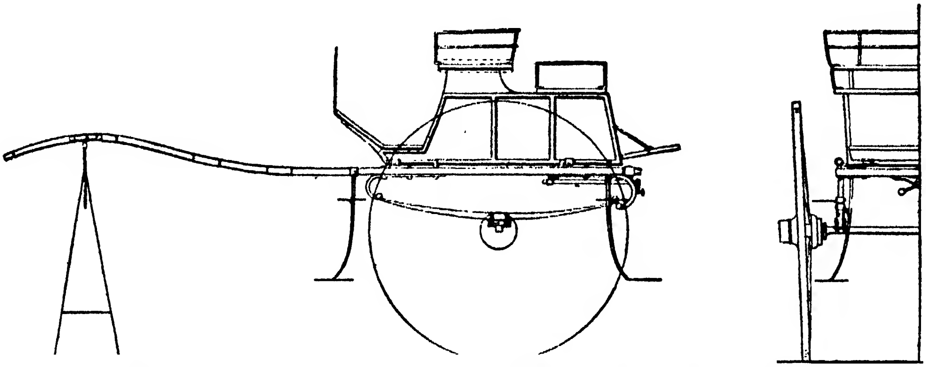
The Cant Board. Coachbuilders of former generations and a good many of the present day are often troubled with the mysteries of the cant board. Having had a preliminary training in two and four-wheeled carts, the bodymaker may be allowed to take a hand in the construction of broughams, landaus, landaulettes, sociables, victorias and barouches. The presence of the side sweep and turnunder in these vehicles, together with boot contractions, necessitates some distinct preparation for the marking off of the tenon and other shoulders and bevels. The cant board is, first of all, a plan. It is not a plan taken in any one place, but the body is shown at the cant rail, elbow and bottom, and

anywhere that an important joint is located. Here we find all these lines plotted together, as it were, on one plane surface. One can see that, with a turnunder, the body is narrower at the bottom than at the elbow, therefore we should expect to find the bottom side line inside the elbow line on the cant. The side sweep decides the plan shape of the cant rail, fence rail, elbow, etc., and we cannot cut off our seat rail lengths unless we see exactly where they come. The difference in length of the various bars across the shoulders is seen exactly, likewise the door pillars planned so as to present a pair of parallel faces between which the glass-frame may slide.

On our cant board, allowance is made for the swing of the door, taking the distance from the hinge centre to the shut pillar as the radius. The driving boot is often narrower across the brackets than at the body. We can show this, thereby enabling the bodymaker to see the length of toe piece, bracket bar, top and bottom boot bars, and the fixing of the boot side. The student will soon realise that the door pillars present a larger surface outside than inside, likewise the door is narrower across its internal dimensions.

The Value of Practical Experience. Many affirm that to be an accomplished draughtsman it is necessary that the actual handling of the tools and workshop routine be undergone, otherwise the individual does not grasp the details of his work in a practical manner. We must not draw a pillar and then add the wasting, or provide a door without means of opening it and providing a safe clearance. But bench work does not always fit a man to go into the office. We may see an experienced mechanic draw a fore-carriage that will never lock, and carefully show the hole for the handle fixing through the standing pillar. Perhaps it is the practical mind unaccompanied with the ability to put such thoughts on paper. Being given a technical knowledge, the beginner should first practise the outline in elevation of simple bodies, adding later the end views and plan. Then he may finish the vehicle throughout by adding the under-carriage, wings, lamps, cushions, and other details. Then types more curved should be taken, and the larger scales before the smaller ones.

The Successful Draughtsman. A draughtsman, whatever vehicle he may undertake, must be in some degree versed in theoretical and applied mechanics, must understand the laws of hygiene as applied to a proper current of air, and maintaining a suitable temperature, and must understand the various physical and chemical changes that materials suffer under varying climatic and other conditions. He will also be called upon to make "blue prints" from his tracings where duplication is necessary. The coachbuilder now uses these, having seen their utility in the prints of the châssis supplied by the motor engineer for the bodymaker's guidance.



30. SIDE ELEVATION AND HALF BACK OF A TANDEM DOG-CART

If one can enjoy drawing as a pastime, the work at the bench has been wisely supplemented. The ambitious workman finds that he can cover a wide range of action with pencil in hand, and a piece of work is constructed sooner on paper, and either passed or rejected, as the case may be.

Teachers in evening classes know how popular drawing is as a subject. It is sometimes rather disappointing to find the announcement of a well-prepared lecture producing a smaller attendance than a scale-drawing night. Many workmen, after a hard day at the shop, will gladly come some distance in order that a couple of hours may be spent in drawing. Try to teach them another branch of their trade, or help them to better themselves in their own particular vocation, and you may find your energy expended in vain. It is not uncommon to find practical evening trade classes and technical drawing classes with a respective attendance of one pupil to seven.

Continued

Continued from page 2603

MORE PROPERTIES OF LIGHT

The Principles of Light, Refraction and Dispersion. Newton's Experiments and their Results. Causes of the Mirage. The Prism

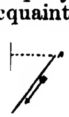
By Dr. C. W. SALEEBY

SOME allusion was made to refraction in the paragraph called *The Law of Least Time* [page 2560]. The word is derived from the Latin *Frango* (I break), and its appropriateness is evident to anyone who has seen the apparent breakage of a pencil partly immersed in a tumbler of water. A still more striking instance of refraction is furnished by the familiar experiment of putting a coin in a teacup, standing so that it is just hidden from the eye by the edge of the cup and then pouring in water. At a certain point the coin will become visible. This means that the rays of light passing from it through the water have been refracted or turned at an angle on passing from the water into the air, so that you are enabled to "see round a corner." The laws of refraction hold true whether we trace the course of light from, for instance, air to water or from water to air. In the first case, the light is bent towards the normal; in the second case it is bent from the normal. (We have seen that the normal is the perpendicular to the surface.) The facts of refraction are very much more important than those of reflection, because they enable us to make discoveries concerning the very nature of light, and because of their value in optical instruments.

The Laws of Refraction. If we state these laws in a double form, the first is identical with the similar law of reflection. The incident ray, the refracted ray, and the normal are all in one plane.

The second part of the law of refraction is much more difficult, and is known as the *law of sines*. Professor Tait thus states the two laws in one sentence: " . . the incident and refracted rays are in one plane with the normal to the surface, and the sines of their inclinations to it are in a constant ratio." This latter part may be otherwise stated, thus: no matter the angle at which the incident light falls upon the refracting surface, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is always the same — for any two given media. This remarkable fact—the law of single refraction—was discovered by Snell, a physicist of Leyden, about the year 1620.

The accompanying figure will allow the reader who is unacquainted with trigonometry to understand the meaning of this law. We have taken equal lengths of the incident ray and of the refracted ray, and from the terminal points of each—*a* and *b*—have drawn perpendiculars to the normal (the dotted lines). Given the same two media, say air and water, the ratio of the one dotted line to the other is *always the same*, no matter at what angle the incident light impinges.



Refractive Index. It is necessary to understand clearly what is meant by the *constancy* of the ratio between the two sines—or between the dotted lines drawn in the conditions of our diagram—in order to be able to understand what is called the *refractive index*. The ratio of the sine of the angle of incidence to that of the angle of refraction is always greater than one when the light passes from a rarer to a denser medium, as, for instance, from air to water. This is only another way of saying that, in such cases, the ray is always bent towards the normal. The converse of this statement is obviously true. It is thus possible to express very briefly the amount of refraction which is characteristic of various media, assuming that in each case the light passes into them from air. The ratio of the sines in the case of the passage from air into water is as 4 to 3, and the term refractive index is applied to this figure; in other words, the refractive index of water is 1·33. This may be compared with the refractive index of the diamond, which is about 2·4. It is this very high value of the refractive index which gives the diamond its brilliance. [See also below.]

A Complication. But the case is not so simple as we have hitherto described. Snell stated the law of simple refraction perfectly, but for one notable exception. He said nothing about the kind of light employed; nor could he, since he did not realise those facts concerning the nature of light which refraction itself has subsequently enabled us to discover. In describing the refractive index for any two media, or for any second medium in relation to air, it is necessary to specify that the light be homogeneous, or all of one wave length. If we employ mixed light, such as white light, its various constituents are differently refracted; thus the figures quoted above are true only for homogeneous yellow light of a given wave length. This the reader already knows, since we have quoted from Newton himself, the discoverer, the statement that "Light itself is a heterogeneous mixture of differently refrangible rays." We may make further quotations from the classical words in which Newton announced his discovery in a letter to a friend.

Newton's Experiment. "In the year 1666 I procured me a triangular glass prism, to try therewith the celebrated phenomena of colours. And in order thereto having darkened my chamber, and made a small hole in my window shuts, to let in a convenient quantity of the sun's light, I placed my prism at its entrance, that it might be thereby refracted

to the opposite wall. It was at first a very pleasing divertisement to view the vivid and intense colours produced thereby; but after a while, applying myself to consider them more circumspectly, I became surprised to see them in an oblong form, which, according to the received laws of refraction, I expected should have been circular. . . Comparing the length of this coloured spectrum with its breadth, I found it about five times greater." He then goes on to describe several modifications of the experiment which he thought might explain the result. For instance, he altered the thickness of his prism and transmitted the light through parts of different thicknesses. He also varied the size of the hole in his shutter and tried placing the prism outside the hole instead of inside, but he always got the same result. Many other suggestions occurred to him, all of which he successively dismissed. One of these is of great interest, since it shows how the mind of the philosopher observes apparent trivialities, and since it suggests an explanation based on the corpuscular theory of light. It has a bearing, too, upon many sports and upon rifle shooting.

"Then I began to suspect whether the rays, after their trajection through the prism, did not move in curve lines, and according to their more or less curvity, tend to divers parts of the wall. And it increased my suspicion when I remembered that I had often seen a tennis-ball, struck with an oblique racket, describe such a curve line. For a circular as well as a progressive motion being communicated to it by that stroke, its parts, on that side where the motions conspire, must press and beat the contiguous air more violently than on the other, and there excite a reluctancy and reaction of the air proportionally greater. And for the same reason, if the rays of light should possibly be globular bodies, and by their oblique passage out of one medium into another acquire a circulating motion, they ought to feel the greater resistance from the ambient æther, on that side where the motions conspire, and thence be continually bowed to the other. But notwithstanding this plausible ground of suspicion, when I came to examine it, I could observe no such curvity in them. And besides—which was enough for my purpose—I observed that the difference betwixt the length of the image and the diameter of the hole, through which the light was transmitted, was proportionable to their distance."

The Crucial Experiment. Finally, Newton tried what he calls the *experimentum crucis*, or crucial experiment, a phrase derived from a celebrated argument of Bacon's in his "Novum Organum." He says:

"I took two boards, and placed one of them close *behind the prism at the window*, so that the light might pass through a small hole, made in it for the purpose, and fall on the other board, which I placed at about 12 ft. distance, having first made a small hole in it also for some of the incident light to pass through. Then I placed another prism behind this second board, so that the light trajected through both the boards might pass through that also, and be again refracted before it arrived at the wall. This done, I took the first prism in my hand, and turned it to and fro slowly about its axis, so much as to make the several parts of the image, cast on the second board, successively pass through the hole in it, that I might observe to what places on the wall the second prism would refract them. And I saw, by the variation of those places, that the light, tending to that end of the image towards which the refraction of the first prism was made, did in the second prism suffer a refraction considerably greater than the light tending to the other end. And so the true cause of the length of that image was detected to be no other than that *light* is not similar or homogeneal, but consists of *difform rays, some of which are more refrangible than others;* so that without any difference in their incidence on the same medium, some shall be more refracted than others; and therefore that, according to their *particular degrees of refrangibility*, they were transmitted through the prism to divers parts of the opposite wall."

Explanation of Refraction. In order to explain the facts of refraction on his own theory of light, Newton assumed that the corpuscles of which he thought light to consist must travel faster in a denser medium—faster in water than in air. But on the wave theory of light we must assume that light travels more slowly in the denser medium, and in such a case the refractive index expresses the ratio between the two velocities. In order to satisfy ourselves on this point, it is necessary to demonstrate experimentally that light moves more slowly in water than in air. This was proved by direct measurement more than half a century ago.

Aerial Refraction. Provided that the air through which light passes be all in the same physical state, the light will travel if straight lines; but if, for instance, the density of the air be changing, its refractive index changes, and the light is constantly being turned in this direction and that. Hence, there is the wavy appearance of the atmosphere which is sometimes noticed, but the most striking instance of this is furnished by the case of a lighted candle or gas-jet. In a church or a concert room everyone has noticed the wavy appearance of the air above such a source of heat. The gas-jet gives rise to currents of hot air which pass upwards in an irregular fashion due to draughts. Looking, then, at a window beyond such currents, it seems to be thrown into vibration.

Refraction and the Setting Sun. Now, we believe that there is an upper limit to the atmosphere. Beyond it the light travels in pure ether alone. When it strikes the atmosphere it should, therefore, be refracted, bent towards the normal just as when it passes from air to water. Naturally the refractive index of the air will become greater as it becomes denser, that is to say, as the light advances towards the earth. The more obliquely the light enters the atmosphere the more marked will be the refraction. These facts are of much

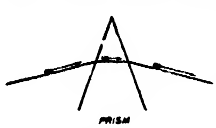
interest in astronomy. It follows from them that when a celestial object is near the horizon, so that the light from it is penetrating the atmosphere very obliquely, refraction is very marked. Thus, at sunrise or sunset the solar disc appears not circular but elliptical, the long axis being horizontal. This is due to the fact that the light from the upper part of the disc is less markedly refracted than that from the lower part.

Let the reader draw for himself a circle representing the surface of the earth, and then a series of concentric circles external to that, representing atmospheric layers of different density. Let him then mark two points, one to indicate an observer and the other the sun below the horizon. Let the solar light be bent towards the normal, again and again, as it passes through the ever-denser atmosphere. Take, then, the final bending, prolong its line, and it will be realised that the sun, or, rather, a *virtual image* of the sun, may be seen, even when the sun himself is below the horizon.

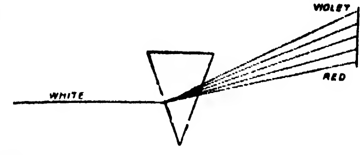
Total Refraction. It follows from the laws of refraction that under certain conditions light must be totally reflected from the surface, refraction being impossible. Thus, in the case of homogeneous light in air that is shining upon water, the refractive index, as we have seen, is about one-third. If, however, the angle of incidence is made extremely oblique the law of sines cannot be satisfied and the light is all reflected from the surface of the water. The case is much more striking, however, if we consider the source of light to be under the water, and the light to be endeavouring to make its way into the air. We have already seen that in such a case the light is bent away from the normal. If the incidence of the light be made more and more oblique, at last the ray is totally captured; the light cannot get out of the water at all, but is all turned back, this being known as *total internal reflection.* The limiting angle of incidence, at which all refraction becomes impossible, is known as the *critical angle.* Light cannot pass from a denser into a rarer medium when its angle of incidence exceeds the critical angle for the case in question. In the case of the diamond the critical angle is very small as compared with glass or water. Indeed, light cannot get out of a diamond except at an angle less than about 23°. If the angle be greater than this the light is totally reflected internally. Hence, the brilliance of the gem.

The Mirage. Just as the laws of refraction explain the visibility of celestial objects which may be actually below the horizon, so the critical angle and total reflection produce the *mirage,* an optical illusion by means of which one may be able to see terrestrial objects which are often really far below the horizon. This occurs where the density of closely adjacent layers of air varies greatly. In the desert, for instance, the air near the ground may sometimes be rarer than the air above it. The mirage may take many different forms, the image sometimes being inverted, sometimes erect, double or single. It occurs, of course, also at sea. The commonest form is where distant objects seem to be reflected in what looks like a lake of water in the heavens. The phenomenon is due to successive refractions through successively denser layers of air until at last a layer is reached at the angle of total reflection. The rays of light are then returned to the eye of the observer.

The Prism. We all know what, in general, is meant by a *prism.* From the present point of view, a glass prism is simply a refracting medium bounded, or partly bounded, by plane surfaces which form an angle with one another. If the surfaces of such a medium be parallel to one another as, for instance, in the case of a thick sheet of glass, the light passing through it is refracted, but emerges from the refractive medium in a course strictly parallel to its previous course. Thus in looking through a sheet of glass the position of objects relatively to one another is not changed. The whole of the light passing through has been refracted; but there has been no modification of the mutual relations of the refracted rays. Very different is the case of the prism. The accompanying diagram shows a prism through which a ray of light is passing, the light being supposed to lie in the plane of the paper. We see that when the light enters the prism it is bent in the direction of its thicker part and again in this direction on emergence.



Dispersion. But now let us suppose that we are dealing with ordinary white light. The prevous quotation of Newton's words will tell us what happens. When Newton made a slit in his shutter he found that the image of it after passage through a prism yielded a band of colour. Newton's experiment can easily be repeated. A mirror placed in the sunlight is used to direct a ray of light through a slit into a dark room, a prism is placed in the path of the ray and a band of colours constituting the spectrum is thrown upon the opposite wall. The technical name for this spreading out of the constituents of white light into a many-coloured band by means of a prism is "dispersion." "The amount," says Professor Tait, "by which any part of this spectrum is shifted from the true position of the bright slit depends (other things being equal) upon the amount of the refraction. It also depends upon the angle of the prism. And, for a given angle, the length of the spectrum depends upon the difference between the refractive indices of the red and the violet rays. This is called the dispersion."



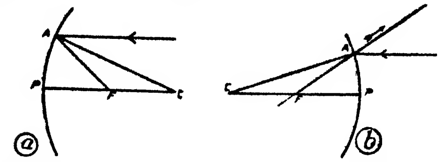
The Correction of Dispersion. If, now, we take a second prism, having the same angle as the first, and place it in the path of the

spectrum, we find that it recombines or gathers together again the dispersed rays, restores the light to its original direction, and yields us the unaltered image of the slit again. This simple experiment of Newton proved once and for all that sunlight is a mixture of all sorts of colours, and that the colour we call *white* is simply the sum of all these. But Newton further concluded from the second experiment that dispersion and refraction go together, since he found that when he corrected the dispersion he also corrected the refraction. In other words, he concluded that the amount of dispersion is, in all substances, proportional to that of the refraction. If this were so, and we combined two prisms made of two different substances, having different refractive indices, and also having different angles, so that the second would exactly annul the dispersion caused by the first—then the refraction would also be annulled. Fortunately, however, as we shall see later, Newton was wrong. Many years afterwards it was discovered that "we have in certain media large refraction with comparatively small dispersion, and vice versâ, and thus that the dispersion may be got rid of while a part of the refraction remains." Previous to this discovery, it had occurred to one observer that the human eye might furnish the key to the problem—for in the eye there are several media *of different kinds*, and their combination permits of refraction with only very little dispersion. To this we shall return when we consider lenses.

A New Complexity. So much for a preliminary discussion, with the irreducible minimum of mathematics, of reflection and refraction at plane surfaces. We must now turn to the difficult questions raised by the incidence of light upon spherical surfaces.

We may begin with reflection at a spherical surface. If we take any point upon the surface of a sphere, we may conceive of a plane which is called the *tangent plane*, and which may be understood best by saying that the plane of a billiard table is the tangent plane to that point where a ball rests upon it. Now, what we have already defined as the normal in such a case must pass through the centre of the sphere. These facts are all that are necessary by way of introduction to the understanding of the behaviour of a spherical mirror. Such a mirror may, of course, have two reflecting surfaces, the one internal or concave, and the other external or convex. Speaking of such a mirror, we define as its centre, or more properly as its centre of curvature, the centre of the sphere of which the mirror forms a part. The mid-point of the reflecting surface of the mirror is called its pole, and the straight line joining the *pole* and the centre of curvature is called the *principal axis*. These terms are quite simple, but the reader will do well to draw diagrams for himself in order to illustrate them. The next term requires a little more care.

The Principal Focus. By the *principal focus* we mean that point towards which the mirror reflects the rays that fall upon it directly—that is to say, in a direction parallel to its principal axis. The diagram shows the incidence of



rays parallel to the principal axis. After reflection such rays all converge to the point F, the law, of course, being followed that the angle of reflection is equal to the angle of incidence. In our diagram AC will represent the normal to the tangent plane at A, and the angles on each side of it must be equal. Hence, it can be easily proved that the point F is midway between P and C—that is to say, we make the assertion that *the principal focus of a spherical mirror lies on its principal axis, half-way between its centre of curvature and its pole.* To this point all rays of light impinging directly upon the mirror are reflected.

If we turn the mirror round, so to speak, and use its external surface so that it becomes a convex mirror, the same is true. The rays turned back from the surface of the mirror indicate the principal focus, which is again the mid-point of the principal axis of the mirror, but in this case, of course, the rays of light do not reach the focus at all, and it is thus a *virtual focus* [see diagram (*b*)].

Spherical Aberration. The simple statement we have made as to the principal focus is, however, not strictly true. The further away the incident rays are from the pole of the mirror the less accurately do they conform to this rule. They pass near the principal focus, but not actually through it. The nearer the principal axis the less is the deviation. The effects of this inexactitude upon the resulting image are technically known as *spherical aberration.* If, however, instead of using a spherical mirror, the section of which is an arc of a circle, we use a parabolic mirror, the section of which is a parabola, all rays whatsoever, parallel to the principal axis of the mirror, are precisely reflected through the principal focus. For astronomical purposes absolute accuracy is necessary—hence parabolic mirrors are always employed for the fine mirrors of reflecting telescopes, and spherical aberration is thus avoided.

Evidently in the case of a spherical mirror any radius is equally able to act as principal axis. On this principal axis there are two points which have a reciprocal relation to one another, such that the rays from either are brought to a focus at the other; they are therefore called *conjugate foci* or focuses (Latin *jugum*, a yolk). We shall afterwards see that lenses have similar properties.

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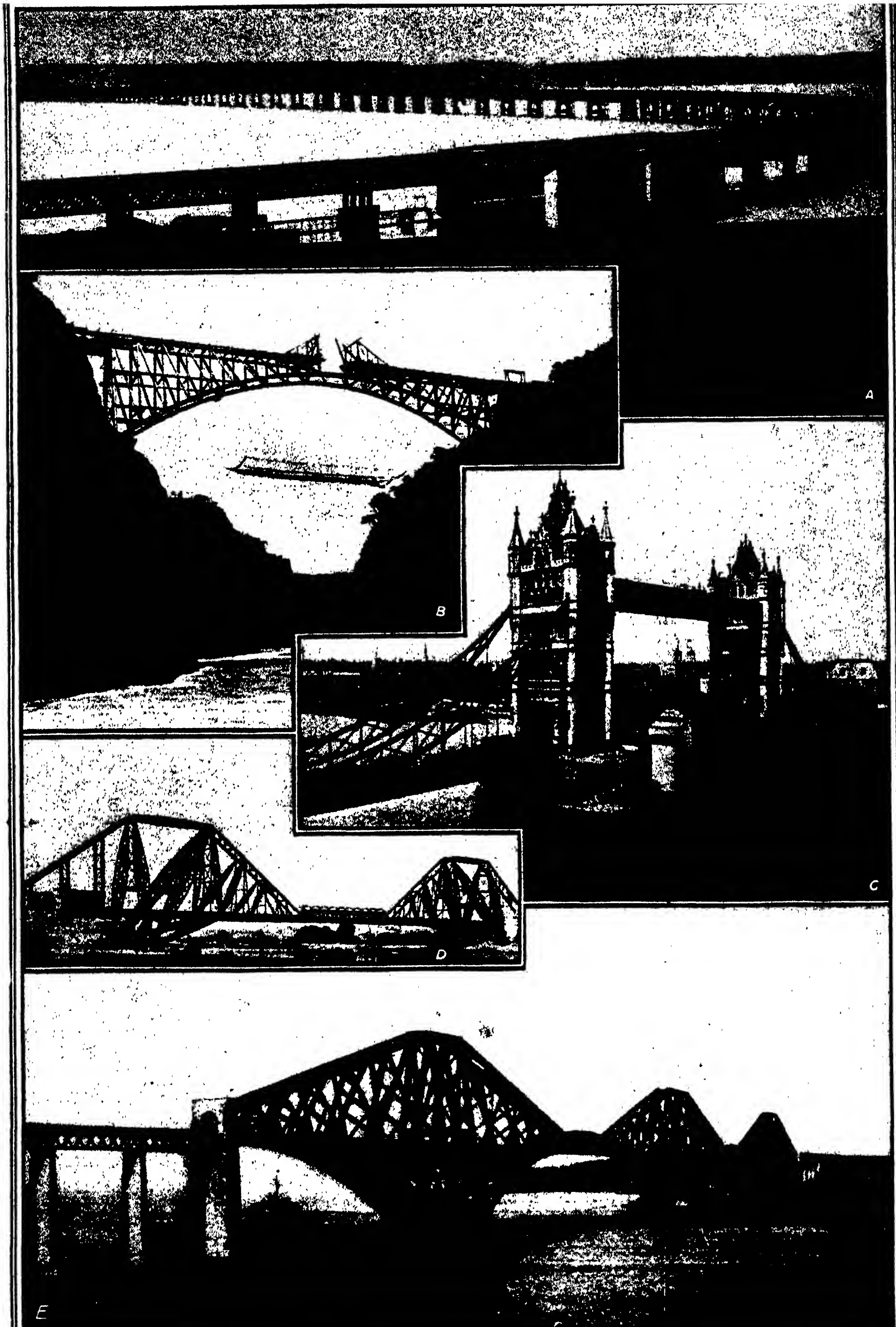


SOME FAMOUS BRIDGES

A. Tay Bridge *B.* Victoria Bridge, Zambesi River, just before completion *C.* Tower Bridge, London
D. Sukkur Bridge, India *E.* Forth Bridge

MODERN BRIDGES

Bridge Foundations. The Cantilever Principle. The Forth, Quebec, and Sukkur Bridges. The Zambesi Bridge

continued from page 2499

By Professor HENRY ADAMS

Bridge Foundations. The engineers of the rising generation having the use of ferro-concrete and steel piling will probably marvel at the temerity of bridge engineers in building upon wooden piles and platforms so late as the nineteenth century, but it has yet to be proved that the newer materials have any advantage. The piles under old London Bridge remained sufficiently sound to support the massive superstructure after nearly 700 years, and the present London Bridge, built in 1828, rests upon a plank and pile foundation. Trajan's bridge across the Danube rested on wooden piles, and one of these, when taken up for inspection after having been in use more than 16 centuries, was found to be petrified to a depth of three-fourths of an inch, but otherwise little altered. Cast-iron piles have been in use since about 1820, but they appear to have been used only for cofferdams and wharf walls.

Rolled-steel Piles. Rolled-steel piles of a pattern practically identical with some of the cast-iron piles of nearly a century ago have been recently introduced. They are particularly suitable for sheeting round foundations, cofferdams [15], and bridge cylinders [16]. When put together the joints run at 12 in. centre to centre, and the shape permits of any outline in plan being followed. For a sudden bend the pile is curved transversely, as 17.

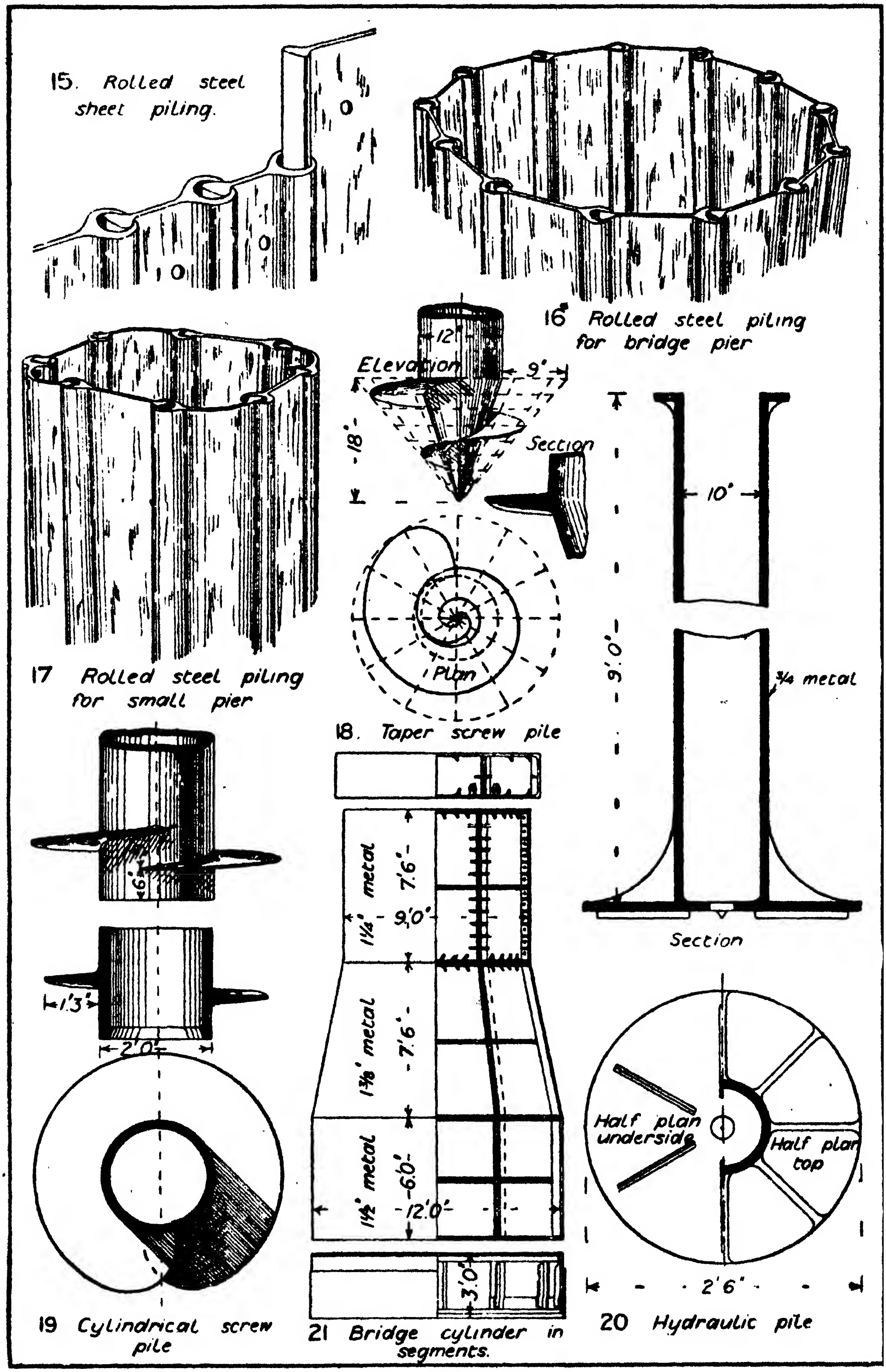
Screw Piles. Small bridges and pier jetties are often carried by screw piles. 18 shows the screw for the lighter cases and 19 for the heavier. The former may be made in a separate casting attached to a wrought-iron or steel column, or may be simply formed on the lowest length of a cast-iron column. The latter is always formed on the bottom length of a cast-iron column, and is usually adopted for column diameters of 12 in. to 30 in. They are screwed in by a temporary timber framing bolted on to the upper flange and rotated like a capstan head by a rope from a crab winch. The width of the screw blade varies according to the nature of the foundation; the largest diameters are used upon sand and peat.

Hydraulic Piles. For similar purposes, hydraulic piles are sometimes used upon a sandy foundation. A railway viaduct was carried across the sands of Morecambe Bay in spans of 30 ft., each pier being composed of two main piles and two raking piles, as 20. The piles were in 9 ft. lengths, and 10 in. diameter outside, with ¾ in. thickness of metal. The discs on the main piles were 30 in. diameter, with an orifice 2 in. diameter for the discharge of water. The mode of sinking consisted of loading the top of each pile and guiding it by a pile engine, pumping water down the pile, and as it escaped through the bottom working the pile backwards and forwards with an alternating rotary motion, so that the cutters on the disc could loosen the marl while the water washed away the sand and fragments. The piles were sunk to an average depth of about 20 ft., and it was calculated that the sand had a supporting power of about 5 tons per square foot when it had settled.

Bridge Cylinders. The foundations for heavy bridges may be of masonry built up within cofferdams or caissons, or may be of cast-iron cylinders filled with concrete. This arrangement is shown in 21. Timber piles are driven at intervals round the site to act as guides to the cylinders, the bottom section, consisting of a steel curb with cutting edges, is put in position, and the cast-iron segments forming the body of the cylinder are then bolted together on the curb with water-tight joints. The cylinder soon begins to sink by its own weight, and the material is then excavated from the interior by hand or by grabs, and additional sections are bolted on at the top. Extra weight is added when necessary to force the cylinder down. Two or more such cylinders are strongly braced together at the top to form a single pier.

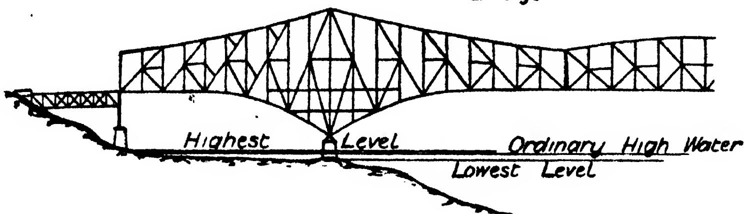
The Cantilever Principle. The greatest advance in modern bridge building for large spans has been due to the advantage taken of the cantilever principle. When a beam is continuous over several spans it is found that between the supports there are two points where the bending moment vanishes; these are the *points of contrary flexure*, or where the tensile stress in the upper portion and compressive stress in the lower portion, above each support, diminish to zero preparatory to their gradual increase to the maximum stresses of the reverse character at the centre of the span. This is the principle of cantilever bridges, of which the Forth Bridge is the most widely known example. It is the same as if cantilevers were built out on both sides of the pier to balance each other, and the cantilevers from adjoining piers then carried an ordinary girder suspended between their points, these points being equivalent to the points of contrary flexure in a continuous beam.

The Forth Bridge. This bridge [22], based upon the cantilever principle, involved nothing theoretically new, but the magnitude of the structure and the marvellous skill shown in the design evoked well deserved praise, and although many subsequent bridges of the same kind may reach a larger span, the chief merit still remains with Sir Benjamin Baker and those allied with him in the work for having been the successful pioneers. The work of erection, although expedited with all the skill and force that modern science could suggest or money could procure, occupied no less than

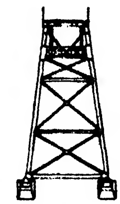


FOUNDATIONS FOR BRIDGES

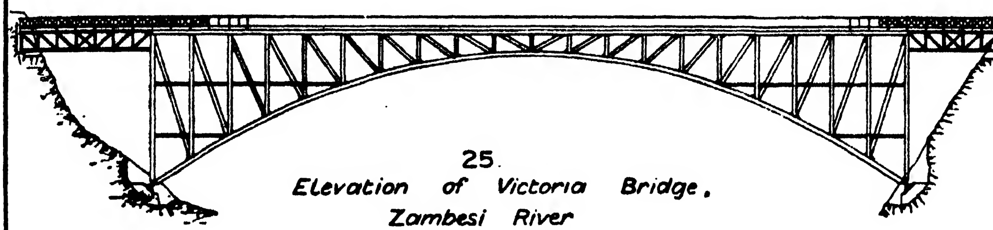
22. Elevation of one span of the Forth Bridge.



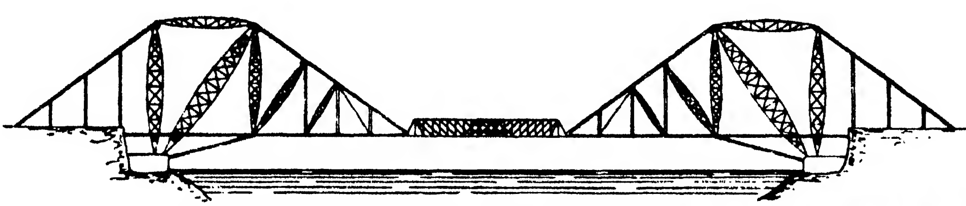
23. Half elevation of the Quebec Bridge



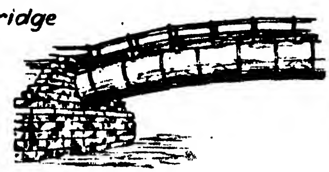
26. Section of 25



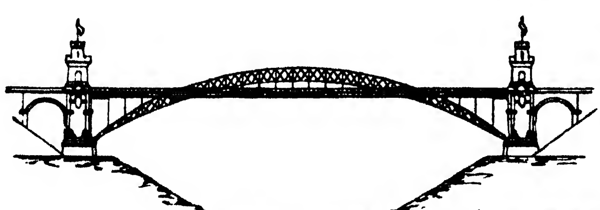
25. Elevation of Victoria Bridge, Zambesi River



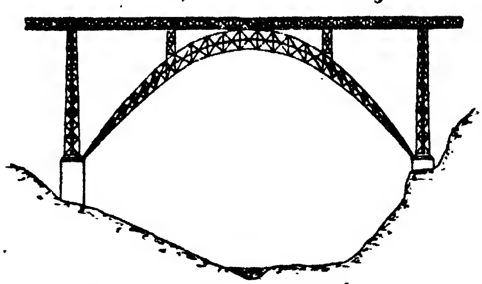
24. Elevation of the Sukkur Bridge

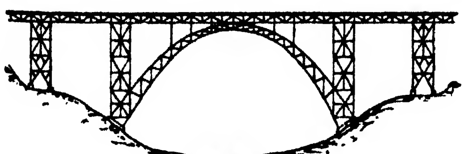


30. Part view of Pipe-Arch Bridge



27 Elevation of the Grünenthal Bridge





29 Elevation of the Müngsten Bridge.

28. Elevation of the Garabit Bridge

MODERN LARGE SPAN BRIDGES

seven years. Altogether it reaches from 90 ft. below high water to 360 ft. above, and is 1½ miles long. The weight of the superstructure is about 45,000 tons, but altogether over 50,000 tons of steel were employed, besides 140,000 cubic yards of masonry and concrete. There is a clear headway for ships of 150 ft. above high-water for a width of 500 ft. at each of the two great openings of 1,710 ft. span, or nearly one-third of a mile. Half the bridge only is shown in **22**.

The Quebec Bridge. The bridge over the River St. Lawrence at Quebec now in course of construction is of the same type as the Forth Bridge. It will have the largest single span in the world, exceeding the Forth Bridge by 90 ft. The total length of the bridge will be 3,300 ft., the length of the channel span 1,800 ft., and the anchor spans 500 ft. each. The cantilevers project over the waterway 562 ft. 6 in., and the central girder carried by their points is 675 ft. span. For a length in the centre of 1,200 ft. there will be a clear headway of 150 ft. above the highest tides. The central depth of the cantilevers is 315 ft., and of the middle girder 130 ft. The arrangement of the bracing is shown in the half elevation [**23**]. The cantilever towers stand 360 feet above the river. The total width of bridge floor is 63 ft. It is intended to carry a double track railway, with an electric track and highway on each side, and two 5 ft. foot-walks.

Material for Large Bridges. In large bridges by far the most serious load is the weight of the structure itself, therefore the strongest material compared with its weight is used. If aluminium would bear comparison with steel in strength, its lightness would render it the material without equal for bridges, but at present mild steel holds the premier position. There is practically a limiting span for any material, according to its strength and weight, beyond which it is impossible to go, and we may consider that this is nearly reached in the case of the Quebec bridge.

The Sukkur Bridge. The Sukkur Bridge over the River Indus is upon somewhat of the same principle as the Forth Bridge, but decidedly less pleasing in appearance, due to the contrast between the braced compression members and the other parts, as shown in elevation in **24**. These three illustrations show some of the variations of which the cantilever principle is capable.

The Zambesi River Bridge. The bridge over the Zambesi at the Victoria Falls, Rhodesia, completed and opened in 1905, is a two-hinged braced and riveted arch span of 500 ft., with lattice girder spans of 75 ft. for the approaches. It weighs 1,650 tons. The arch trusses have a rise of 90 ft., a depth of 105 ft. at the skewbacks, and 15 ft. at the crown. This bridge is remarkable from its position, being built across a rocky gorge about 650 ft. wide, with precipitous cliffs of hard basalt on each side. The front elevation and section are shown in **25** and **26**.

The Grünenthal Bridge. Steel-braced arch bridges have been erected of many different designs; there would, in fact, seem to be almost unlimited scope for variation. The Grünenthal Bridge over the Baltic Canal [**27**] consists of a single span of 513 ft. 6 in., with an arched girder of bold proportions having a rise of 78 ft. 6 in. and a straight line of roadway running through it. The effect is, on the whole, very satisfactory.

The Garabit Bridge. The Garabit Bridge over the River Truyere in France [**28**] has a similar arch with pivoted ends, but sunk entirely below the roadway. The span is 541 ft., and the arch has the enormous rise of 196 ft. 9 in. There are theoretical reasons for reducing the braced arch to a mere pin bearing at the ends, but the effect is hardly agreeable when it is remarked that in all arches the thrust is greatest at the springing.

The Müngsten Bridge. The opposite characteristic is seen in the Müngsten Bridge [**29**], which is otherwise of a similar character. This bridge is 560 ft. span and has the enormous proportionate rise of 250 ft. The arch is deepened towards the abutments, where it is ingeniously framed in with the braced towers supporting the roadway.

Pipe Arch Bridge. A novel bridge was recently erected over the River Sudbury near Saxonville, Massachusetts. It forms part of the aqueduct that carries the Boston water supply, and consists of a steel arched pipe [**30**] 7 ft. 6 in. diameter, and ⅜ in. thick, double riveted. The span is 80 ft. and the rise 5 ft. 6 in. To resist the great thrust on the abutments, about 40 ft. of solid concrete was filled in behind them. Some difficulty was experienced in handling this work, both in the shops and in the field, owing to its unusual character, but it would be impossible to imagine a simpler solution of an awkward question.

Long Span Bridges of the Future. So far back as 1867 Sir Benjamin Baker, in a book entitled "Long Span Railway Bridges," showed that of eleven different types of bridge, which included every class of design, not absolutely eccentric, that which he called the *continuous girder of varying economic depth* was the one capable of being built to the greatest span. This type was practically identical with that afterwards adopted for the Forth Bridge. By mathematical investigation he showed that the limiting span was theoretically 2,500 ft. in wrought iron, at which span with an infinite quantity of material and a strain of 80 cwt. per square inch, the bridge could not carry more than its own weight. With steel having a value of 130 cwt. per square inch compared with 80 cwt. for wrought iron, he showed that the limiting span would be 4,000 ft. The practical limit would, however be reached at about half these spans, owing to the excessive cost due to the great weight of material involved in the wider spans. We can hardly anticipate the introduction of any new principles of design, but we may hope that improvements in steel will enable higher strains to be safely reached, and the saving in weight that this will effect will enable still wider spans to be crossed if occasion should arise.

Continued

VIOLIN BOWING

Function and Balance of the Bow. How Effects of Light and Shade are Obtained. Advantages of Combined Playing. Compass of the Violin Family

By ALGERNON ROSE

F the foregoing remarks it should be evident that the violinist's left hand has a very important office. All the finger technique which a keyboard player has to master with both hands, in the violinist devolves on his left hand alone. As the majority of human beings are right-handed rather than left-handed, we have hitherto treated specially of the manner in which the less exercised member is employed.

The Hands. Not only does accurate intonation depend on the way in which the left fingers stop the notes, but the quality of the tone is influenced by the manner in which the digits move, and the rapidity of such motions is the first necessity for velocity in execution. Moreover, D'Arpentigny, in his interesting book on "La Science de la Main," draws attention to the fact that the most correct and thorough musicians are characterised by having what are known as spatulate fingers, such as are numerous amongst mathematicians and algebraists, strict observance of time and measure being the necessarily precedent condition of musical rhythm. Musicians, then, whose finger-tips are spade-like in shape, are generally those who can play in time most accurately. On the other hand, the same authority shows that melody is the peculiar province of fingers which are pointed. Such are less reliable in an orchestra, although they are more capable of taking the world by storm in solo work. Where both forms are combined, as was the case with Paganini and Liszt, executive musical powers appear to reach their culmination.

Should the student, then, possess thick, square-ended fingers, he will, as a rule, find it wise to give more attention to the cultivation of melody and expression in playing, than if he has fine-pointed fingers, in which case, his chief care should be accuracy in time, as playing in tune will come more naturally to him. Be that as it may, correct movements of the right hand are as essential to the violinist as those of his left, for the right hand manipulates the bow. Without it the violin makes no musical appeal, inasmuch as the right hand and arm movements supply the necessary mechanism for the production of the tone, just as the keys, levers, and other parts of the complicated double escapement, check and hammer action do in the pianoforte.

Nuances. If the left hand of the violinist is indispensable for the production of tone, semitones, intervals and nodes, it is the right hand of the player which furnishes not alone the vibration, but the *piano, dolce, forte. fortissimo, smorzando, diminuendo, calando,* and all the other subtle shades or nuances which go to make up expression in playing. The student should understand that the development of tone-quality is something infinitely more than mere loudness or softness. Accuracy of fingering may be the first essential, but unless this is allied to skill in bowing, the result is colourless and uninteresting. A graceful and effective handling of the fiddle-bow is a fine art. The bow represents more to the violinist than do the keys to the pianist. When well managed it is the fiddler's loud and soft pedal. It acts also in the capacity of the swell shutters of an organ.

But whereas pedal effects are produced mechanically on a keyboard instrument, the violin student must train his right hand and arm to furnish the mechanism, and before he can use the bow with dexterity, long and careful practice is indispensable. But a charm of the violin and its bow is that the two invariably reward merit and show no consideration for persons. Thus, the needy but good player with a cheap fiddle and cheap bow, who by practice has made himself expert, will obtain a better effect than the bad player, although he possess a priceless Strad.

Function of the Bow. Neat execution in violin playing is only possible by adroit bowing. An orator may have a good voice, just as a fiddler's left hand may give correct intonation; but it is the speaker's knowledge of the art of delivery which influences and stirs up the emotions of his audience. Hitherto the student, if he has followed the directions given, has endeavoured to bow with regularity and straightness of direction—we have not confused him by describing the many varieties of expression obtainable by the right hand. It is now impossible for him to give too much attention to the different styles of bowing. For these he will find that sometimes the whole bow is used, and at others the half bow; and that the lower, the middle, and the upper parts of the bow each have their duties.

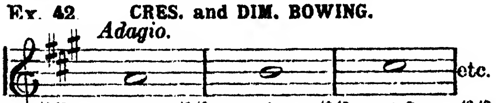
Open Strings. The student should endeavour to infuse light and shade into the four open notes by varying the side-pressure of the bow as they are played. To get the most delicate softness of expression, which was such a charm in the playing of the great Paganini, the straightness of the bow may now slightly be departed from. For ordinary purposes the stroke of the bow should be midway between the end of the fingerboard and the bridge. But the softest effect is obtained when the bowing is done close to the end of the fingerboard, whilst the sound is most brilliant when the bow approaches the bridge firmly.

Now begin at the tip slowly. Put the point loosely on the string, lower down than usual. Push the bow upwards, increasing both the pressure and the speed as well as the direction, in order to get a uniform crescendo. The stroke should be so regulated that it has its maximum firmness as the hair approaches most closely to the bridge. This should be when the middle of the bow passes over the string. Then, continuing the motion, cause the sound to diminish in the same way by small degrees, so that when the nut of the bow reaches the string the tone is almost inaudible.

Simple as this exercise may appear, it needs considerable practice to do well. In lessening the pressure and rapidity of the stroke, the player aids the effect by imperceptibly elevating the bow whilst he moves it further from the bridge. To do this skilfully requires flexibility of wrist, so that the entire weight of the bow never presses down vertically on the string. Now try Ex. 42. Practise the effect with the down-bow on each note of the scale, placing the nut of the bow very delicately on the string nearer the finger-board than usual. Bring the bow down with increasing strength and a backward movement of the arm, so that the speed is greatest at the middle, when the hair is closest to the bridge. Power over the bow, it will be perceived, is mainly produced by the thumb, forefinger, and wrist. It is only when the bow approaches the bridge that its weight is sustained principally by the little finger. This relaxes its tension naturally as the bow descends.

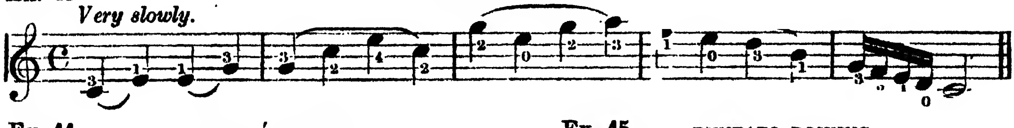
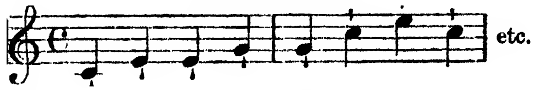
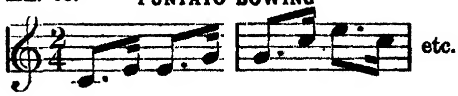
Legato. A curved line in the music, which links two or more notes together, indicates that all must be played with the same stroke of the bow. The notes being tied together, the manner in which they are played is known by the Italian word *Legato*. Bend the wrist carefully on approaching the bridge. The longer a note is sustained, the greater, as a rule, is the length of bow used. Therefore, begin a long slurred passage either close to the tip or the nut [Ex. 43].

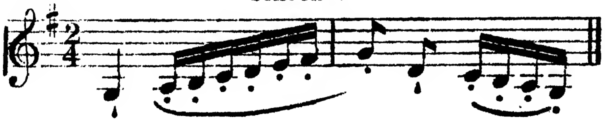
Ex. 42 CRES. and DIM. BOWING.



Legato playing is a very important branch of execution for the learner to acquire. It is a fine art to make the sounds of the string flow continuously, so that whether the bow is at its heel or tip, or is changing the stroke, the effect produced is equal. Without regular practice, the most naturally gifted violinists have not acquired the ability to bow smoothly, and thus compensate for casual lack of strength in the left hand, or subdue spasmodic exhibitions of unusual digital power. When Opie was asked how he mixed his colours, he replied, "With brains." Any great violinist when questioned how he contrives to bow so gracefully can give the same answer. Not alone the hands, but brains must be employed if the learner is to make progress. After lengthy practice it often happens that the conscientious student perceives that he is playing worse instead of better. He should feel encouraged by such a belief instead of being disheartened. Unknown to himself, he has raised his own standard of musical appreciation, and is aiming higher than he did at first. He is beginning to be a true artist, and the greater the excellence to which he attains the more will he in secret feel dissatisfied with himself.

Balance of the Bow. Apart from sustaining the tone with different degrees of strength, the bow, as the source of expression, gives to violin music its accent. Slurs of moderate length are begun about the middle, where quick, full notes are generally played with the last quarter of the bow. After first seeing that the hair is clean, practise short, quick slurs in order to improve the balance of the bow. The weight of the two ends of the stick being unequal, the wrist of the player must accustom itself to neutralise this inequality, and place the bow on the strings at any given point at the right angle so that the bow is in a constant state of equipoise, ready to do whatever is required of it with the least effort. To get balance of the bow, play from the nut, using, at most, 3 in. of the hair for each slur. Grasp the stick almost rigidly with all the fingers. Do not take the bow off the strings nor the fingers from the stick. The pressure of the hair on the strings should be light, and the notes should flow evenly and be neither hard nor harsh.

Ex. 43. LEGATO BOWING

Ex. 44. DETACHÉ BOWING

Ex. 45. PUNTATO BOWING

Ex. 46. STACCATO



Ex. 47. MARTELÉ

The *detaché*, or separated, style of bowing is used when a short, emphatic note and its successors are played firmly with equal power and duration. Keep the elbow perfectly still and the back of the arm steady. Make the strokes as long as possible. To produce equality, put a little more vigour in the up than in the down bows [Ex. 44].

Puntato. Not only is richness of expression gained, but interest is added by studying the same exercise, bowing it in a different way. What is known as *puntato*, or pointed, bowing is the firm playing of dotted notes with the tip, keeping the bow on the strings. For strengthening the right wrist, Ex. 45 will be found an excellent drill.

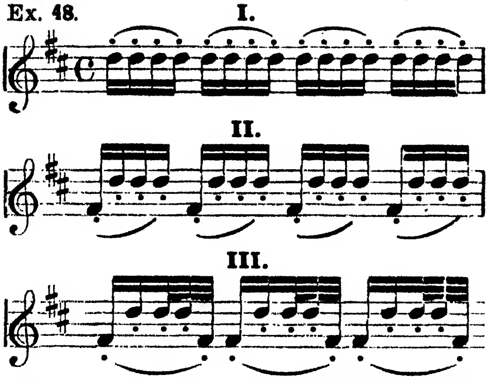
Very like puntato, only more separated, is the opposite style of bowing to legato. This is called *staccato*, one of the most brilliant, bright, and beautiful of bowings. The thumb should now press the stick lightly. Start the series of detached notes, or chips of sound, from the tip in an up-bow, or the middle of a down-bow. The latter is the more difficult. In the former, the upper half of the bow is always used. With one stroke the disjoined percussive notes must be articulated clearly, smartly, and in strict time. Such notes are marked in music by dashes or dots above or below them.

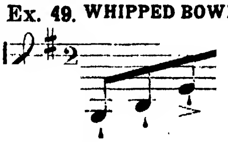
Nothing but intelligent practice will lead to a mastery of rapid staccato bowing. No unbowed instrument is capable of giving the peculiar staccato effects which can be made by skilled players of the fiddle tribe. Although the production of this feature is purely mechanical, and some performers show an exceptional faculty for its accomplishment, others fail to properly acquire the knack. Imagine the hair of the bow to represent a 2-ft. rule marked vertically with sixteenth divisions of an inch. In playing a passage of notes staccato, endeavour to employ only one of these sections for sounding each note. Begin slowly. After each short thrust, stop. Never go backwards and forwards; let the stroke always advance. Good staccato players can execute long passages softly, articulating each note clearly without the bow having visibly crossed the strings any distance. The reason why the staccato is easier to do with the upper than the lower half of the bow is because, in the latter case, the weight above is liable to make the bow spring and take away from the firmness and dryness of the effect [Ex. 46].

Changing the Stroke. When the length of the bow does not suffice to execute a note or notes within the time indicated, the change of stroke must always be done very smoothly with no diminution of power, so that no interruption may be heard if in the middle or towards the end of a passage.

This style, known also as the *Martellato*, means "hammered." It consists in detaching notes from each other with the upper part of one bow, causing the hair to dwell for a moment on the string so as to damp the sound instantly and give the effect of a little knock. If, after a special direction like "Martelé," the word "segue" occurs in the music, it implies that the preceding style of bowing is to be resumed, or literally "followed" [Ex. 47].

Ex. 48.



Ex. 49. WHIPPED BOWING

Tremolando. *Tremolando* implies a shivering or wavering tonal effect. It is indicated by a short waved line under a long note or chord. Tremolando is executed by the note being bowed with a loose wrist and considerable rapidity. The arm must be free and the little finger lifted. Necessary pressure to make the bow bite, but without exaggeration, is supplied by the second and first fingers together with the thumb. There are three kinds of tremolando bowings. The first is a prolonged shiver on one note. The second is a rapid arpeggio over two strings, the first note being followed by a second thrice reiterated. The third variety is when one note is followed by a second repeated thrice as before and ends with the first note, the last three sounds of the group being taken twice as fast as the first two.

Begin in each case with a sharp jerk of the wrist, as if shaking drops of water off a wet hand. This gives the impetus for the spring of the bow and the recoil stroke, the motion of the right hand for tremolando bowing being ellipsoidal instead of straight down and up [Ex. 48].

Fouetté. *Fouetté*, or whipped, bowing is done by the bow being lifted off the string and thrown on it sharply with an up-stroke near the point so that it does not tremble [Ex. 49].

Arpeggio Bowing. This means in the style of a harp. Some old writers spelt the word "harpeggio." In arpeggios on all the four strings of the fiddle the first care must be to get correct intonation. The more awkward the fingering the greater must be the attention paid to getting each note in tune. If the student tires during this study, he should turn to something easier. The effect should be a series of soft percussive pulsations, the elasticity of the bow causing it to bound easily from string to string. Begin by slurring the note on the four strings before attempting to make the bow dance. The knack will come gradually. At first the bow will have a habit of dancing two or three times on the same string. With

practice this irregularity will be cured. Never exaggerate the dancing. Make it quietly. Remember that arpeggio notes should be played consecutively with a smooth, harp-like effect. The middle of the bow is used mostly for four-string arpeggios. Keep the hair flat on the strings and the stick more to the left than usual. Ex. 50 gives three bars from an excellent study by Spohr.

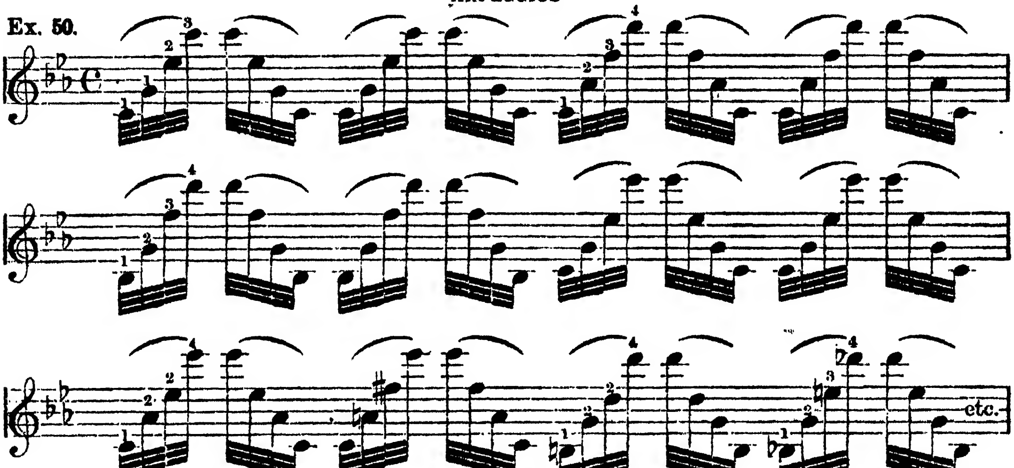
Saltato. *Saltato*, or sautillé, is a peculiar staccato effect obtained by making the bow bound and rebound on a string quickly, or whilst see-sawing across the strings as in extended arpeggios; but the effect is more "jumpy" than before. First tighten the bow. When the faculty has been acquired, the degree of force used can be varied. Keep the tip of the little finger rigidly on the stick. Relax the other fingers. Hold the bow half an inch above the string—the part of the bow used is the middle. Drop it in such a manner that the hair shifts a fraction of an inch and the note is bowed as well as struck. The natural recoil brings the bow back for the next hop. Now try tripping on the strings, steadily increasing the height from which the bow falls; but the stick must not be allowed to strike the strings through the hair [Ex. 51].

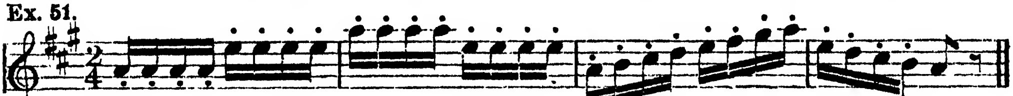
Col Legno. *Col Legno*, as the Italians say, means "with the wood," or *Le Dos de l'Archet*, as the French say, means "with the back of the bow." Wagner, Boildieu, Liszt, Strauss, and other composers, have made use of this effect to produce weirdness in orchestral colouring. When the words occur, the player simply turns his bow over and makes the wood chatter on the strings, or scrapes them as directed. The effect is rarely employed, and the student need not trouble about it.

Pizzicato. *Pizzicato* for the right hand is of far more importance. The term implies that the strings are pinched or plucked so as to give a guitar effect; meanwhile the right hand holds the bow firmly near the nut by the last three right fingers. There are two ways of executing right-hand pizzicatos. First, when the passage is a short one, the violin remains under the chin. Place the tip of the right thumb against the lower edge of the fingerboard. With the first finger, pluck the string or strings until the words "col arco" occur in the music and the bow is again used. The second way of making pizzicato is employed when the passage is a long one. It is then more convenient and productive of a fuller tone to hold the violin like a guitar. Retain the bow in the right hand as before. This time put the first finger against the edge of the fingerboard. Do the plucking with the thumb. Keep the nails short; if they are long, not only is the tone bad, but the strings are liable to be cut.

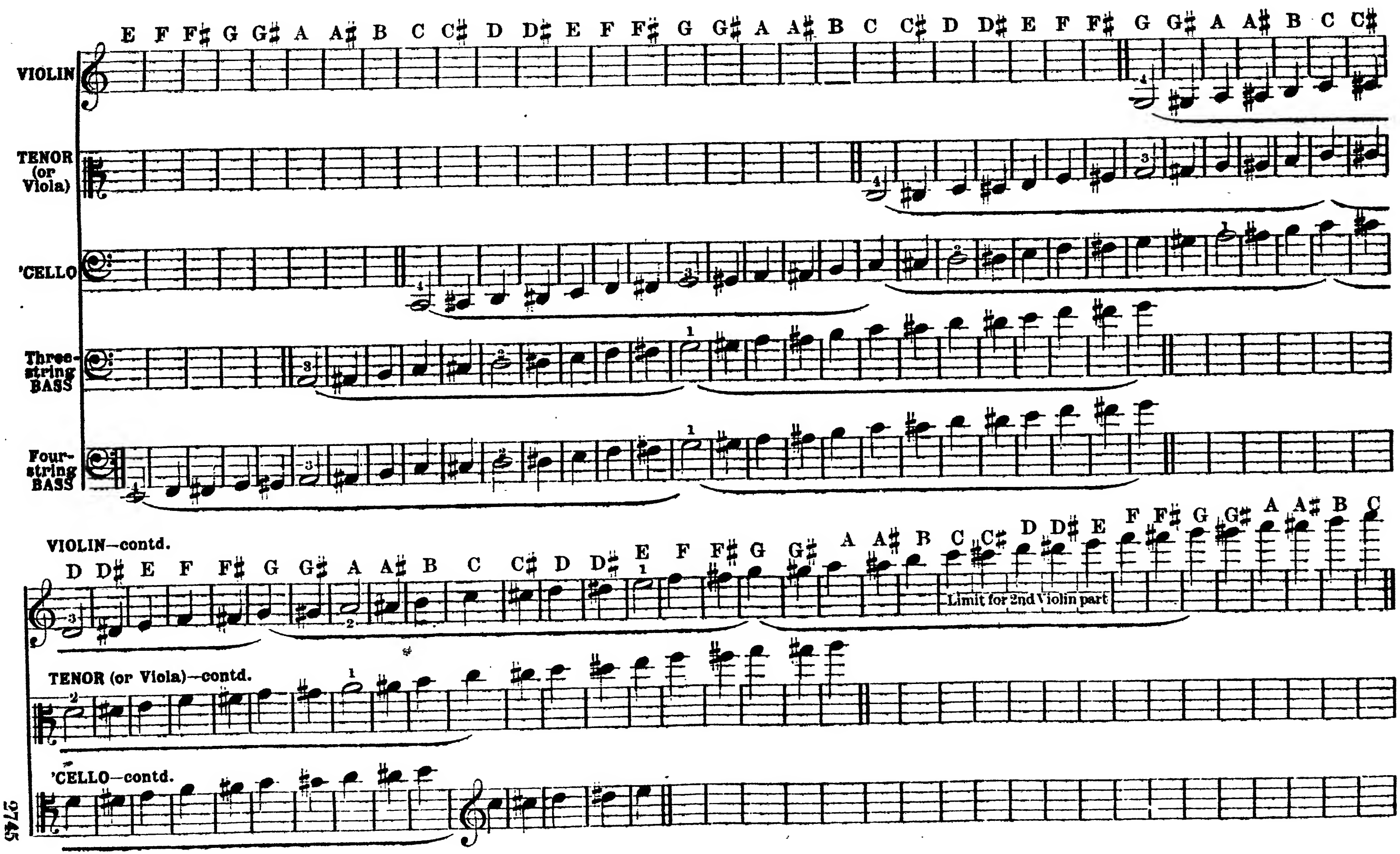
ARPEGGIOS

Ex. 50.



Ex. 51.

Mind Training. Let us repeat that all bowings must be practised slowly at first and with great care. Mark Hambourg says that "it is as important to train the mind as the fingers if one would be a great instrumentalist," and he further remarks that unless the whole heart and soul of a pianist is working with his fingers, he may as well leave the piano alone. This observation applies even more to the violinist, who supplies the mechanism of h own instrument. As the student becom familiar with the correct ways of bowin speed can be increased.

Before a violinist can co-operate usefully an successfully with other players, he should ha reached a fair stage of individual proficienc First, he ought to be able to play in tun

THE COMPASS OF THE VIOLIN FAMILY

next, by reasonable mastery of the bow, he should be able to express the shades of tone marked in the music; and, last but not least, he must have the faculty of keeping time so that he does not hurry over easy passages nor "drag" during difficulties. Unqualified fiddlers are the ruin of most amateur orchestras. Professor Prout, echoing Schumann, has said that "Bach's 48 Preludes and Fugues should become the daily bread of the pianist." In like manner, Kreutzer's 40 delightful studies should be the diurnal diet of the violinist. They can be purchased for 1s. 6d. from Boosey. In most towns nowadays there are amateur orchestral societies, or choirs accompanied instrumentally. As soon as possible the student should seek election as a second violinist in such a body.

Advantages of Playing with Others. The experience gained by the student who does this will teach him much that cannot be appreciated during solitary practice. First, playing with others will train him to read at sight. Secondly, it will open up to his mind a large province of good music hitherto unexplored by him. Thirdly, if the conductor knows his work and the orchestra is competent to follow his directions, the student who is familiar with some well-known composition will learn how a different complexion may be given to it by a distinctive manner of "reading." Fourthly, what is known as syncopated playing, or altering the rhythm by driving the accent to that part of a bar not usually accented, is often more easily acquired in association with others than when bowing alone. Fifthly, the student, especially at concerts, will have an opportunity of gaining valuable hints from artists engaged who are better players than himself. Sixthly, he will thereby, if he keep his ears and eyes open, be able to correct shortcomings in his own playing, and so develop his natural gifts whilst avoiding undesirable mannerisms in others.

Family Intercourse. The student's purest enjoyment, however, will probably be found as soon as he is capable of taking part in a stringed quartet or quintet. Wonderful as his instrument is by itself, or when played in unison with other fiddles in an orchestra, it is related by the closest of family ties to a set of larger instrumental brethren, all equally remarkable in their way. These extend the compass downwards. During harmonious intercourse with its kindred, therefore, the first violin is representative of the soprano voice, the second violin of the contralto, the viola of the tenor, the violoncello of the bass, and the double bass of the basso profondo in a quintet, outrivalling in height and depth of tone that of the contrasting human voices.

To excel as a soloist on the concert platform, a mastery of the most complicated difficulties is demanded nowadays. Although, unlike the pianoforte, the violin attained its highest mechanical development long ago, there seems to be no end to the way in which records of skill and virtuosity are beaten by one player after another. Parents have often wished that their children might have old heads on young shoulders. That miracle has frequently happened of late as regards violin playing. Extraordinary executive perplexities are overcome with ease by many a child-prodigy. The little boy Mischa Elman—to say nothing of Max Darewski—and the tiny girl Vivien Chartres reveal in public a matured insight into the meanings of advanced compositions for this instrument. In such cases the child has usually been brought up in a musical atmosphere. Unconsciously, good music has been nourishing the mind as bread or meat have been building up the body. If, therefore, the self-instructor desires to excel on the violin, we cannot add better advice than this: "Do not fritter away time. Economise it. There is much to be done and life is short. To make rapid progress, the student should take every opportunity of associating with better players than himself. Go as often to concerts as possible. If not good enough to play second fiddle in an orchestral society, volunteer to help the librarian or steward to put out the music." By keeping his ears open, the student will then hear much to help and stimulate his practice.

Books. Of books calculated to enthuse the lover of the violin, sometimes obtainable cheaply secondhand, we may mention "Famous Violinists," by Henry Lahee; the "Autobiography" of Louis Spohr—as interesting as any novel—"The Violin," by Dubourg; "The Bow: Its History, Manufacture, and Use," by H. Saint-George; and that delightful work "The Violin: Its Famous Makers and Their Imitators," by George Hart.

Methods. The most notable methods are those of Kreutzer, Rode, and Baillot, as used at the Paris Conservatoire; and the tutors by Spohr, Alard, David, and Dancla—soiled copies of which are frequently procurable from the secondhand book shops in Charing Cross Road, London, at a nominal price.

Examinations. A sure way of testing progress and ascertaining that the student is on the right road is to work up for the graded examinations of the Incorporated Society of Musicians. Write to 19, Berners Street, London, W., for particulars. These tests are held periodically in all the chief centres of Great Britain and Ireland, and the British Colonies. The examinations are in four classes, the maximum of marks given being 100 in each grade. In the easiest class, the marks are allotted as follows: Scales, 12; Arpeggios, 8; a Study, 25; a Piece, 40; Questions, 10; and Ear-tests, 5. The points which are particularly considered by the examiners are correctness of intonation, strictness of time, the fingering employed, the phrasing and accentuation, the attitude of the player, and the manner of his bowing.

In conclusion, we give the compass of all the different members of this important musical family [52].

Violin concluded

ALGEBRAIC FACTORS

Monomial Factors. Factors by Grouping Terms. Use of Formulæ. Difference of Two Squares. Sum or Difference of Two Cubes

continued from page 2560

By HERBERT J. ALLPORT, M.A.

FACTORS

53. We have already considered how the product of two or more algebraical expressions is formed. In simple cases we can do the converse of this; that is, when we are given the product we can find the factors which were multiplied together to make that product. This is called the *resolution into factors* of the product.

54. Monomial Factors. When each term of an expression contains a common factor we can divide the whole expression by that factor.

Example 1. Every term of $2x^3 - 4x^2 + 6x$ is divisible by $2x$.

Thus,

$$2x^3 - 4x^2 + 6x = 2x(x^2 - 2x + 3).$$

Example 2.

$$34a^2x^4 + 51a^4x^3 = 17a^2x^2(2x^2 + 3a^2).$$

EXAMPLES 11

Resolve into factors

1. $x^3 + 6x$.
2. $a^2 + ab + ac$.
3. $11a^2b^2c - 33abc^3$.
4. $3x^4 - 2x^2y^2 + xy^3$.
5. $5y^4 - 20xy^3$.
6. $39xy^2z + 45yz^2$.
7. $6ax^3 + 4a^2x - 8a^3$.
8. $68 - 51x^2$.
9. $114a^4bc^2 + 95ab^2c^2$.

55. Factors Found by Grouping the Terms. Many expressions can be resolved into factors by a suitable grouping of the terms. At present we shall only notice the case where one of the letters involved always occurs in the *same power*. Generally, if we group together the terms which contain that letter, a factor of the expression becomes evident.

Example 1. Resolve into factors $ab + b^2 + bc + ac$.

Here, we notice that when a occurs in any term it is always of the *first* degree. We therefore group together the terms which contain a, thus $(ab + ac) + b^2 + bc$. We now take out the factor a from the first two terms, and the factor b from the last two, obtaining $a(b + c) + b(b + c)$. It now becomes obvious that $(b + c)$ is a factor of the whole expression. If, in fact, we suppose for a moment that $(b + c)$ has the value x, the expression would be $ax + bx$; and this is of the same *form* as the examples considered in Art. **54**, so that its factors are $x(a + b)$. That is, the given expression is equal to $(b + c)(a + b)$.

Hence, our working appears as follows,

$$\begin{aligned} &ab + b^2 + bc + ac \\ &= a(b + c) + b(b + c) \\ &= (b + c)(a + b) \ \underline{Ans.} \end{aligned}$$

Notice that the above is not the *only* way of grouping the terms. We should have found the factors just as easily by grouping together the terms bc and ac, since they contain c in the first degree only, and c occurs in no other term.

Example 2. Resolve into factors

$$a^2 + a(b + c + d) + d(b + c).$$

Here d only occurs in the *first* power. Therefore we have

$$\begin{aligned} &(ad + bd + cd) + (a^2 + ab + ac) \\ &= d(a + b + c) + a(a + b + c) \\ &= (a + b + c)(a + d) \ \underline{Ans.} \end{aligned}$$

The first line of the above working is not really necessary. The student should find no difficulty in at once writing the given expression in the form $d(a + b + c) + a(a + b + c)$.

Example 3. Resolve into factors $a^2b^2c^2 - b^2c - a^2c + 1$.

Given expression

$= a^2c(b^2c - 1) - (b^2c - 1)$

[by taking together the first and third terms. Note that in putting $-b^2c + 1$ into brackets we change the signs (Art. **19**); in reality we are taking out the factor -1.]

$= (b^2c - 1)(a^2c - 1)$ $\underline{Ans.}$

EXAMPLES 12

Resolve into factors

1. $x^2 + ax + bx + ab$.
2. $ab^2 + b^2 + a + 1$.
3. $ax^2 - (a + b)xy + by^2$.
4. $ac + bc - ad - bd$.
5. $x^2y^2 - 2x^2 + 2y^2 - 4$.
6. $ax - 2by + 2ay - bx$.
7. $x^3 - ax^2 + x - a$.
8. $ax - ayz + bcx - bcyz$.
9. $x^4 + 2x^2(y^2 + z^2) + 4y^2z^2$.
10. $x^3y^3 + 2ay^3 - 3ax^3 - 6a^2$.

56. Factors by Comparison with Formulæ. In Art. **31** and those immediately following we obtained several *general* results in multiplication. If a given expression is of the *same form* as any of these results we can write down its factors by inspection. For example, in Art. **32**, we showed that

$$(x + a)^2 = x^2 + 2ax + a^2.$$

If, then, we have an expression which consists of the square of one quantity *plus* the square of another, together with twice the product of the two quantities, we know at once that the expression is equal to the square of the sum of the two quantities.

Example 1. The expression $x^2 + 4ax + 4a^2$ consists of the square of x, the square of $2a$, and twice the product of x and $2a$. It follows that the expression is the square of $x + 2a$. Thus,

$$x^2 + 4ax + 4a^2 = (x + 2a)^2.$$

Example 2. Resolve $4a^2 - 12ab + 9b^2$ into factors.

In this case $4a^2$ is the square of $2a$, $9b^2$ is the square of $(-3b)$, and $-12ab$ is twice the product of $2a$ and $(-3b)$. Hence $4a^2 - 12ab + 9b^2$ is the square of the sum of $2a$ and $-3b$, or

$$4a^2 - 12ab + 9b^2 = (2a - 3b)^2.$$

If the terms have a common factor, this factor must be removed first, as in Art. **54**.

Example 3. Resolve $12a^2b^2 - 3a^3b - 12ab^3$ into factors.

Here, $3ab$ is a factor of every term. Therefore we have

$$\begin{aligned} 12a^2b^2 - 3a^3b - 12ab^3 &= 3ab\,(4ab - a^2 - 4b^2) \\ &= -3ab\,(a^2 - 4ab + 4b^2) \\ &= -3ab\,(a - 2b)^2. \end{aligned}$$

EXAMPLES 13

Resolve into factors

1. $x^2 + 4x + 4$.
2. $y^2 - 6y + 9$.
3. $25a^2 - 20ab + 4b^2$.
4. $-6a^2 - 3a^4 - 3$.
5. $4x^4 + 8x^2y + 4y^2$.
6. $2a^2x^2 + 2a^2b^2 + 4a^2bx$.
7. $(x + y)^2 + z^2 + 2z\,(x + y)$.
8. $(a + b)^2 - c\,(a + b) + \frac{1}{4}c^2$.

57. In Art. **31** we found that

$$(x + a)\,(x + b) = x^2 + (a + b)\,x + ab.$$

From this it is evident that if such an expression as $x^2 + 5x + 6$ is the product of the two binomial factors $x + a$, $x + b$, then $a + b$ must equal 5 and ab must equal 6. That is, we have to find two numbers whose sum is 5 and whose product is 6. These are easily seen to be 2 and 3. Hence,

$$x^2 + 5x + 6 = (x + 2)\,(x + 3).$$

Example 1. Find the factors of $x^2 + 14x + 24$.

Here we require two numbers whose sum is 14 and whose product is 24. We examine, then, pairs of numbers whose product is 24, viz., 24 and 1, 12 and 2, and so on, until we find the pair whose sum is 14. Therefore,

$$x^2 + 14x + 24 = (x + 12)\,(x + 2) \ \underline{\textit{Ans.}}$$

Example 2. Find the factors of $x^2 - x - 30$.

We require two numbers whose sum is -1 and whose product is -30. Since their product is *minus* 30, the numbers must be of opposite signs. Hence, their algebraical sum will be found by taking one number from the other and prefixing the sign of the greater of the two [Art. **14**]. We have thus, in effect, to find two numbers whose product is 30 and whose *difference* is 1. Proceeding as in Ex. 1 we find the numbers are 5 and 6. It is now easily seen that the numbers whose product is -30 and sum is -1 are 5 and -6. Hence

$$x^2 - x - 30 = (x + 5)\,(x - 6) \ \underline{\textit{Ans.}}$$

Example 3. Find the factors of $a^2 - 7ab + 12b^2$.

The introduction of the letter b does not cause any fresh difficulty. We have to find two quantities whose product is $12b^2$ and whose sum is $-7b$. Since the product is to be positive, the two quantities must be either *both* positive or *both* negative [Art. **21**]. Since their sum is to be *negative*, they must both be negative. Evidently, then, the quantities required are $-3b$ and $-4b$. Hence,

$$a^2 - 7ab + 12b^2 = (a - 3b)\,(a - 4b) \ \underline{\textit{Ans.}}$$

NOTE. If the product of the required quantities is at all large, it is easier to find them if we first put the product into *prime* factors. We have then to separate these factors into two groups, and test whether the factors of these groups form the quantities we require. For example, suppose we want two numbers whose product is 540 and whose difference is 12. Put 540 into its prime factors, 2 . 2 . 3 . 3 . 3 . 5. Then, by repeated trials, we eventually find that 2 . 3 . 3 and 2 . 3 . 5 (*i.e.*, 18 and 30) are the two numbers whose difference is 12.

EXAMPLES 14

Resolve into factors

1. $x^2 + 3x + 2$.
2. $y^2 - 8y + 15$.
3. $x^2 - 3x - 28$.
4. $a^2 + 14a - 51$.
5. $y^2 - y - 240$.
6. $x^2 - 25x - 150$.
7. $y^2 + 51y + 50$.
8. $a^2 - 17ab + 42b^2$.
9. $x^2 - xy - 182y^2$.
10. $x^2 - 27xy + 176y^2$.
11. $2x^2 + 24xy - 90y^2$.
12. $3a^2 - 6ab - 504$.

58. In the last article the highest power in the expression to be factorised had unity for its coefficient. We have now to consider the case in which the coefficient is not unity. Suppose we form the product of the two binomials $2x - 3$ and $3x - 4$. Multiplying both terms of the first by each term of the second, we obtain

$$\begin{aligned} (2x - 3)\,(3x - 4) &= 6x^2 - 9x - 8x + 12 \\ &= 6x^2 - 17x + 12. \end{aligned}$$

Now, in the converse operation, we are given the expression $6x^2 - 17x + 12$ and have to get back to the factors $2x - 3$ and $3x - 4$. This would be very simple *if we knew that the term* $-17x$ *had been obtained from* $-9x$ *and* $-8x$, and not from any other pair of terms, such as $-20x$ and $+3x$. Our first aim, then, must be to find these two numbers 9 and 8. This is easily done if we notice that their product, 72, is the same as the product of the other two coefficients, 6 and 12, in the expression $6x^2 - 17x + 12$; for we have only to find two numbers whose product is 72 and whose sum is 17.

Hence, to factorise the expression $6x^2 - 17x + 12$, *the sign of the third term being* +, we

(i.) Multiply the first and last coefficients, 6 and 12, obtaining 72.

(ii.) Find two numbers whose product is 72 and whose *sum* (since the sign of the third term is +) is 17. These are easily seen to be 9 and 8.

(iii.) Separate the term $-17x$ into the two terms $-9x$ and $-8x$, thus obtaining $6x^2 - 9x - 8x + 12$.

We can now take a common factor $3x$ from the first two terms, and a common factor -4 from the last two; and the rest of the process is like that of Art. **55**. Thus

$$\begin{aligned} 6x^2 - 17x + 12 &= 6x^2 - 9x - 8x + 12 \\ &= 3x\,(2x - 3) - 4\,(2x - 3) \\ &= (2x - 3)\,(3x - 4). \end{aligned}$$

59. Again, we have

$$= 6x^2 - x - 12.$$

and, exactly as before, the chief point is to find that $-x$ was obtained from $-9x + 8x$. Now, since these two terms are of opposite sign, they are combined by *subtracting* the absolute values of their coefficients.

Hence, to factorise the expression $6x^2 - x - 12$, *the sign of the third term being* $-$, we

(i.) Multiply the first and last coefficients, 6 and 12, obtaining 72.

(ii.) Find two numbers whose product is 72 and whose *difference* (since the sign of the third term is $-$) is 1, the coefficient of x. The two numbers are 9 and 8.

(iii.) Since the middle term of the given expression is *minus*, we put the sign $-$ before the greater of the two numbers, thus separating the middle term into the two terms $-9x$ and $+8x$.

The rest of the process is the same as before.

$$\begin{aligned} 6x^2 - x - 12 &= 6x^2 - 9x + 8x - 12 \\ &= 3x(2x - 3) + 4(2x - 3) \\ &= (2x - 3)(3x + 4). \end{aligned}$$

Example **1.** Find the factors of $10x^2 + 37x + 7$.

Here, we require two numbers whose product is 10×7, or 70, and whose *sum* (since the sign of the third term is $+$) is 37. These are easily seen to be 2 and 35. Therefore

$$\begin{aligned} 10x^2 + 37x + 7 &= 10x^2 + 2x + 35x + 7 \\ &= 2x(5x + 1) + 7(5x + 1). \\ &= (5x + 1)(2x + 7). \end{aligned}$$

Example **2.** Find the factors of $4x^2 + 3xy - 27y^2$.

We require two numbers whose product is 4×27, and whose *difference* (since the sign of the third term is $-$) is 3. These are found to be 12 and 9. [See Note, Art. **57**.] The middle term is *plus* $3xy$, so we take $+12xy$ and $-9xy$. Thus,

$$\begin{aligned} 4x^2 + 3xy - 27y^2 &= 4x^2 + 12xy - 9xy - 27y^2. \\ &= 4x(x + 3y) - 9y(x + 3y) \\ &= (x + 3y)(4x - 9y). \end{aligned}$$

EXAMPLES 15

Put into factors

1. $2x^2 - 5x + 2$.
2. $6x^2 + 19x + 15$.
3. $21x^2 - 5xy - 4y^2$.
4. $26x^2 + 87xy - 14y^2$.
5. $132x^2 - 13x - 2$.
6. $9x^2 + 142x - 32$.
7. $17x^2 - 88xy + 15$.
8. $12x^3 - 28x^2 + 8x$.
9. $110x^3y + 58x^2y^2 - 24xy^3$.
10. $8x^2 - 34x + 8$.

60. In Article **38** it was proved that

$$x^2 - a^2 = (x + a)(x - a).$$

Thus, if an expression can be written as the difference of the squares of two quantities, its factors consist of the sum of the two quantities and the difference of the two quantities.

Example **1.** Find the factors of $16x^2 - 25y^2$.

The expression is the difference of the squares of $4x$ and $5y$. Hence

$$16x^2 - 25y^2 = (4x + 5y)(4x - 5y).$$

Example **2.** Put into factors $8x^3y - 2xy$.

$$\begin{aligned} y - 2xy &= 2xy(4x^2 - 1) \\ &= 2xy\{(2x)^2 - (1)^2\} \\ &= 2xy(2x + 1)(2x - 1). \end{aligned}$$

Example **3.** Put into factors $(3x + y - z)^2$

Given expression

$$\begin{aligned} &= \{(3x + y - z) + (x - y + z)\}\{(3x + y - z) - (x - y + z)\} \\ &= (3x + y - z + x - y + z)(3x + y - z - x + y - z) \\ &= 4x(2x + 2y - 2z) \\ &= 8x(x + y - z). \end{aligned}$$

In some cases a slight modification is necessary before the two squares become evident.

Example **4.** Find the factors of $x^4 - 21x^2y^2 + 4y^4$.

Here, x^4 is the square of x^2 and $4y^4$ is the square of $2y^2$. Also, if we square the expression $(x^2 + 2y^2)$ we obtain $x^4 + 4x^2y^2 + 4y^4$. Now, to make this identical with the given expression we must subtract $25x^2y^2$. Hence,

$$\begin{aligned} x^4 - 21x^2y^2 + 4y^4 &= (x^2 + 2y^2)^2 - 25x^2y^2 \\ &= \{(x^2 + 2y^2) + (5xy)\}\{(x^2 + 2y^2) - (5xy)\} \\ &= (x^2 + 5xy + 2y^2)(x^2 - 5xy + 2y^2). \end{aligned}$$

Example **5.** Resolve into factors $4x^4 - 28x^2 + 9$.

If, in this case, we take $(2x^2 + 3)^2$ we obtain $4x^4 + 12x^2 + 9$, and have to subtract $12x^2 + 28x^2$, *i.e.*, $40x^2$, to make it equal to the given expression. But $40x^2$ is not a perfect square, so that this transformation does not help us. If, however, we try $(2x^2 - 3)^2$, we still obtain $4x^4$ and $+9$, but the sign of the $12x^2$ becomes *minus*, and we have then to subtract $16x^2$, which *is* a perfect square. Hence,

$$\begin{aligned} 4x^4 - 28x^2 + 9 &= (2x^2 - 3)^2 - 16x^2 \\ &= (2x^2 + 4x - 3)(2x^2 - 4x - 3). \end{aligned}$$

EXAMPLES 16

Resolve into factors

1. $x^2 - 121$.
2. $a^2 - 16b^2$.
3. $1 - 25y^2$.
4. $a^2b^2 - 49$.
5. $36 - x^2y^2$.
6. $32x^2 - 18y^2$.
7. $(2x + 5y)^2 - (x - 3y)^2$.
8. $(a + 2b)^2 - (a - 2b)^2$.
9. $9(a + b)^2 - (a - b)^2$.
10. $a^4 - 6a^2 + 25$.
11. $x^4 - 40x^2y^2 + 4y^4$.
12. $y^4 - 6y^2 + 1$.

61. By multiplication we find that

$$(x + a)(x^2 - ax + a^2) = x^3 + a^3$$

an

These formulæ enable us to factorise expressions which are either the sum or the difference of two cubes.

Example **1.** Resolve into factors $8a^3 + 27b^3$.

This is the *sum* of the cubes of $2a$ and $3b$. The expression is therefore divisible by the *sum* of $2a$ and $3b$. The terms of the other factor are the square of $2a$, the square of $3b$, and the product of $2a$ and $3b$, the product term being negative. Thus

$$8a^3 + 27b^3 = (2a + 3b)(4a^2 - 6ab + 9b^2).$$

Example **2.** Resolve into factors $27x^3 - \frac{8}{x^3}$.

This is the *difference* of the cubes of $3x$ and $\frac{2}{x}$, and is therefore divisible by the *difference*

of $3x$ and $\frac{2}{x}$. The other factor is formed in the same way as before, but the product term is positive. Hence,

$$27x^3 - \frac{8}{x^3} = \left(3x - \frac{2}{x}\right)\left(9x^2 + 6 + \frac{4}{x^2}\right).$$

EXAMPLES 17

Resolve into factors

1. $a^3 + 125b^3$.
2. $27a^3 - 64b^3$.
3. $x^6 - 8y^6$.
4. $2x^5 + 16x^2y^3$.
5. $(a + 2b)^3 - a^3$.
6. $8a^3 - \frac{64}{b^3}$.
7. $(a - 2b)^3 - (b - 2a)^3$.
8. $\frac{x^3}{343} - \frac{27}{x^3}$.
9. $\frac{a^3b^3}{1000} + 125$.

62. By division, Art. **42**, we proved that

$$a^3 + b^3 + c^3 - 3abc = (a + b + c)(a^2 + b^2 + c^2 - bc - ca - ab).$$

Therefore, when an expression consists of the sum of the cubes of three quantities diminished by three times their product, it can be resolved into factors by means of this formula.

Example. Resolve $8x^3 - y^3 + 6xy + 1$ into factors.

Here $8x^3$ is the cube of $2x$, $-y^3$ is the cube of $-y$, 1 is the cube of 1. Also, 3 times the product of $2x$, $-y$, and 1 is $-6xy$. Therefore,

$$\begin{aligned} &8x^3 - y^3 + 6xy + 1 \\ &= (2x)^3 + (-y)^3 + 1^3 - 3(2x)(-y). \\ &= (2x - y + 1)(4x^2 + y^2 + 1 + y - 2x + 2xy). \end{aligned}$$

Answers to Algebra

Examples 9

1. Let x = greater number. Then, since their difference is 7, the less number is $x - 7$. Therefore $x + x - 7 = 63$, so that $x = 35$. Hence the required numbers are 35 and 28.

2. Let x = the number. When multiplied by 3, the product exceeds 18 by $3x - 18$. Also, the original number is less than 18 by $18 - x$. Hence $3x - 18 = 18 - x$, which gives $x = 9$.

3. Let x = the greater part. Then $39 - x$ = the less. Twice the greater is $2x$, and three times the less is $3(39 - x)$. Hence $2x + 2 = 3(39 - x)$, so that $x = 23$. The two parts are therefore 23 and 16.

4. Let x = the third part. Then, the second part is 3 more than thrice x, *i.e.*, $3x + 3$ = the second part. The first part = twice the second $= 6x + 6$. The sum of the three parts is 69, so that $x + 3x + 3 + 6x + 6 = 69$; whence $x = 6$. Thus, the third part is 6; the second part is $3x + 3$, or 21; and the first part is twice 21, or 42.

5. Let $2x$ = the number. Then, one more than its double is $4x + 1$, and one less than its half is $x - 1$. Its square is $4x^2$. Hence $(4x + 1)(x - 1) = 4x^2 - 10$. Therefore $4x^2 - 3x - 1 = 4x^2 - 10$, or $3x = 9$, and $x = 3$. The required number is twice x, *i.e.*, 6.

6. Let x years = the son's present age. Then $3x$ years = the father's age. In 12 years the father will be $3x + 12$, and the son will be $x + 12$. Hence $3x + 12 = 2(x + 12)$, which gives $x = 12$. Therefore the son's age is 12 years, and the father's is 36.

7. Let x years = age of eldest. Then $x - 5$ = age of second, and $x - 5 - 3$, or $x - 8$ = age of youngest. Therefore $x + x - 5 + x - 8 = 47$, whence $x = 20$. Required ages are 20 years, 15 years, 12 years.

8. Let x pounds = amount A has. Then, since A and B have £39 between them, $39 - x$ = number of pounds B has. Similarly, since A and C have £31 between them, $31 - x$ = number of pounds C has. But B and C together have £26. Therefore $39 - x + 31 - x = 26$, whence $x = 22$. Thus, A has £22, B has £17, and C has £9.

9. Let x = number of crowns. Then $81 - x$ = number of shillings. The total value in sixpences $= 10x + 2(81 - x)$. Again, the value in sixpences of x florins and $(81 - x)$ half-crowns $= 4x + 5(81 - x)$. Therefore $10x + 2(81 - x) = 4x + 5(81 - x)$, whence $x = 27$. Thus, there are 27 crowns and 54 shillings.

10. Let x = cost of an orange, in pence. Twelve oranges cost $12x$ pence, *i.e.*, $(12x - 10)$ pence over 10d. Similarly, 20 oranges cost $(30 - 20x)$ pence under half-a-crown. Therefore $12x - 10 = 30 - 20x$. Hence $x = 1\frac{1}{4}$. Since an orange costs $1\frac{1}{4}$d., the number which can be bought for 5s. is 5s. ÷ $1\frac{1}{4}$d., *i.e.*, 48.

11. Since 4 sides of the one carpet measure 16 feet more than 4 sides of the other, the side of the first is 4 feet longer than the side of the second. Therefore if x feet = side of smaller carpet, then $x + 4$ = side of the other. Their areas will be x^2 square feet and $(x + 4)^2$ square feet. Hence $(x + 4)^2 - x^2 = 64$; which gives $x = 6$. The sides of the two carpets are 6 feet and 10 feet.

12. Let x = number of sovereigns. Then $3x$ = number of half-crowns, and $26 - x - 3x$, or $26 - 4x$ = number of shillings. The total value is £6. Hence, expressing everything in sixpences, we have $40x + 15x + 2(26 - 4x) = 240$, whence $x = 4$. Thus, there are 4 sovereigns, 12 half-crowns, and 10 shillings.

13. Let x = number of shillings A has. If he gives B ten shillings, A has $(x - 10)$ shillings left. This is three times as much as B now has, *i.e.*, B now has $\frac{x - 10}{3}$ shillings. Therefore B originally had 10s. less than this, *i.e.*, $\frac{x - 10}{3} - 10$. If, then, B gave A five shillings, A would have $(x + 5)$ shillings and B would have $\frac{x - 10}{3} - 10 - 5$. Therefore, since this makes A have 4 times as much as B, $x + 5 = 4\left(\frac{x - 10}{3} - 15\right)$. Multiply by 3, and remove brackets, $3x + 15 = 4x - 40 - 180$, so that $x = 235$. Thus A has 235s., or £11 15s., and B has $\frac{235 - 10}{3} - 10 = 65$s. = £3 5s.

14. Let x = the middle number. The number before x is $x - 1$, and the number following x is

$x+1$. The product of these three is to be 5 less than the cube of x. Hence $x(x-1)(x+1) = x^3-5$, or $x^3 - x = x^3 - 5$. Therefore $x = 5$, and the required numbers are 4, 5, 6.

15. The number is *increased* by reversing the digits, therefore the units' digit is the greater. Hence, let $x =$ the tens' digit. Then $3x =$ the units' digit, and the number is $10x + 3x$, or $13x$. If the digits be reversed the number is $30x + x$, or $31x$. Therefore $31x - 26x = 10$. Thus $x = 2$, and the required number is 13×2, or 26.

Examples 10

1. Let $x =$ the greater number, and $y =$ the less. Then $x + y + 2 = 5(x-y)$ and $3x - 4y = 7$. The solution of these equations gives $x = 17$ and $y = 11$.

2. Let x years $=$ the father's age; $y =$ the son's. In another year the father will be $(x+1)$ years and the son $(y+1)$ years. Therefore $x + 1 = 4(y + 1)$. Two years ago the father was $x-2$; in another 3 years the son will be $y + 3$. Therefore $x - 2 = 3(y + 3)$. From these two equations we get x, the father's age, $= 35$ years, and y, the son's, $= 8$ years.

3. Let $x =$ the digit in the tens' place, and $y =$ the digit in the units' place. Then the number is $10x + y$. This exceeds 5 times the sum of the digits by 7. Hence $10x + y - 7 = 5(x + y)$. Again, $10y - x$ is the number formed by reversing the digits, and this is 9 less than the original number. Hence $(10x + y) - (10y + x) = 9$. From these we get $x = 3$, $y = 2$, so that the required number is 32.

4. Let £x = amount A has. Then $2x$ = amount C has. Let £y = amount D has. Then $3y$ = amount B has. Total is £100, so that $x + 2x + y + 3y = 100$, *i.e.*, $3x + 4y = 100$. Again, C and D together have $2x + y$. This is £$2\frac{1}{2}$ more than B. Hence $2x + y = 3y + 2\frac{1}{2}$, or $4x - 4y = 5$. Solving the equations, we get $x = 15$, $y = 13\frac{3}{4}$. Thus A has £15, B has $3 \times$ £$13\frac{3}{4}$, or £41 5s., C has £30, and D has £13 15s.

5. Let x years = elder son's age, y years = younger's age. In 2 years the elder will be $x + 2$. Therefore the father will then be $3(x + 2)$. Similarly, the younger will be $y + 2$, and the father will therefore be $5(y + 2)$. Hence $3(x + 2) = 5(y + 2)$, or $3x - 5y = 4$. Again, since in 2 years' time the father will be $3(x + 2)$, his present age is $3(x + 2) - 2$, or $3x + 4$. Therefore, since in 23 years his age equals the sum of his sons' ages, we have $3x + 4 + 23 = x + 23 + y + 23$, or $2x - y = 19$. Solving the two equations, we get $x = 13$, $y = 7$. Thus, the father's present age is $3x + 4$, *i.e.*, 43 years, the elder son is 13, and the younger 7.

6. Let x = number of miles A walks per hour, and y = number B walks per hour. In 8 hours A walks $8x$ miles, and in 5 hours B walks $5y$ miles. Therefore $8x - 5y = 8$. Again, in 9 hours B walks $9y$ miles, and in 10 hours A walks $10x$ miles. Therefore $9y - 10x = 1$, whence $x = 3\frac{1}{2}$, $y = 4$, and the required rates are A, $3\frac{1}{2}$ miles per hour; B, 4 miles per hour.

7. Let x = number of shillings in the amount A has, and y = number of shillings in the amount B has. Therefore $x + y = 21$. Now B has $12y$ pence. If, then, A gives B $12y$ shillings, B will then have $y + 12y$, or $13y$ shillings; A will have $x - 12y$ shillings. Hence $13y - (x - 12y) = 5$, or $25y - x = 5$. These equations give, by addition, $y = 1$. Therefore B has 1s., and, consequently, A has 20s.

8. Let x = number of miles A goes per hour, and y = number B goes. To go 60 miles A will take $\frac{60}{x}$ hours, and B will take $\frac{60}{y}$. Hence $\frac{60}{x} - \frac{60}{y} = 5$. Again, if A's rate had been $2x$ miles per hour, he would take $\frac{60}{2x}$, *i.e.*, $\frac{30}{x}$ hours to go 60 miles. Hence $\frac{60}{y} - \frac{30}{x} = 5$. Adding these equations, we get $\frac{30}{x} = 10$. Therefore $x = 3$ miles per hour. By substitution $\frac{60}{y} = 15$, or $y = 4$ miles per hour.

Continued

continued from p. 2606

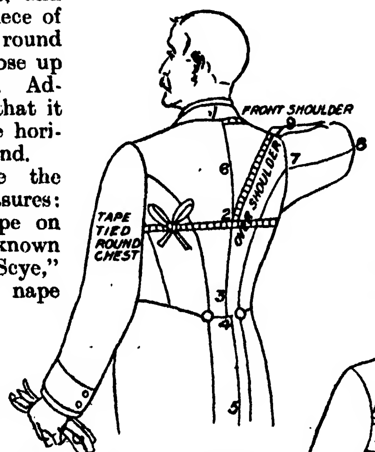
MEN'S COATS

Taking Measurements. Drafting Lounge, Morning, and Dress Coats. The Frock Coat. Scale of Measurements and Variations

By W. D. F. VINCENT

Coat and Vest. The fewest measures that are usually taken are: Nape to natural waist, 1 to 3; nape to fashion waist, 1 to 4; nape to full length, 1 to 5; width of back, 6 to 7; centre of back to elbow, 6 to 8; centre of back to wrist, 6 to 9 [**15**]; chest circumference, 13; waist circumference, 14; hip circumference, 15 [**17**]. These measures are sufficient for proportionate customers, but for others we advise the taking of four additional measures. Fasten coat in front, and then tie a piece of tape or string round the figure close up to the arms. Adjust this so that it is in the true horizontal all round.

Then take the following measures: Nape to tape on back seam, known as "Depth of Scye," 1 to 2 [**15**]; nape to tape at front of arm, 1 [**15**] to 12 [**17**]. From tape on back seam 2 [**15**] over the shoulder to the tape on the front of arm 12 [**17**], known as the "Over Shoulder." From the front of one arm to the front of the other arm, known as the "Across Chest" [**16**].



15. BACK MEASUREMENTS

These measures would stand as follows for a Lounge Jacket: Depth of scye 19; natural waist, 17; full length, 30; back width, 6¾, to elbow, 20, to cuff, 32; front shoulder, 12½; over shoulder, 17; across chest, 8; chest, 36; waist, 32; hips, 37½.

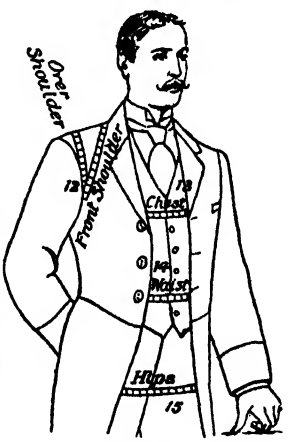
As many may have to work from others' measures, we give in the accompanying table a scale of measurements from 24 to 50 breast, arranged not so much with a view to proportion as the result of practical experience.

	Lounge.	Morning Coat.	
24	20		12¾
25	22	22½	
26	24	25	
27	26	27½	
28	28	30	15¼
30	28½	31	
32	29	32	
34	29½	33	17½
37	30	33½	18½
39½	30½	33½	19½
42	31	34	20
46	31½	34	21
50	32	34	22
54		34	23

Three-seam Lounge Jacket [**18**]. Draw line 0—30; 0 to 3, one-third depth of scye; 0 to 9, depth of scye; 0 to 17, natural waist length; 0 to 30, full length plus ½ in. Draw lines at right angles. 0 to 2½, one-twelfth breast less ½ in.; 2½ to ¾, ¾ in.; 17 to ½, ½ in. Draw back seam from 0 through ½ to 30. Two inches below 3, measure across from the back seam the width of back plus ½ in., curve out to ⅜; Draw shoulder seam from ¾ to ⅜, slightly hollowing it at ⅛; ¼ to 20¼, the half chest plus 2 in. to 2½ in.; 20¼ to 12¼, the across chest; 12¼ to 18¼, 6 in. (always). From 18¼ drop down 2 in. Square a line from 12¼ through C at right angles to 12¼ and 2. Measure up from 12¼ the front shoulder measure less the width of back neck. Measure up from 12¼ to B the over shoulder measure, less ¼, to A of the back. Make C to

16. FRONT MEASUREMENTS

B ¼ in. less than ¾ to ⅜ of back. Shape scye from B to 12¼ and round the back scye up to ⅜. Keep it as hollow as possible at 12¼ and rather close up at back scye.



17. WAIST AND HIP MEASUREMENTS

THE SIDE SEAMS. ½ to 6½ is one-sixth breast. Square down from 6½ and continue line up to 7½ into scye; 6½ to 7½ about ¾ in. Let fore part overlap back ½ in. more than half the difference between chest and hips; 7½ to 10, 2½ in. to 3 in.; 7½ to 10½, 2½ in. to 3 in.; 10½ to 11¼, ¾ in.

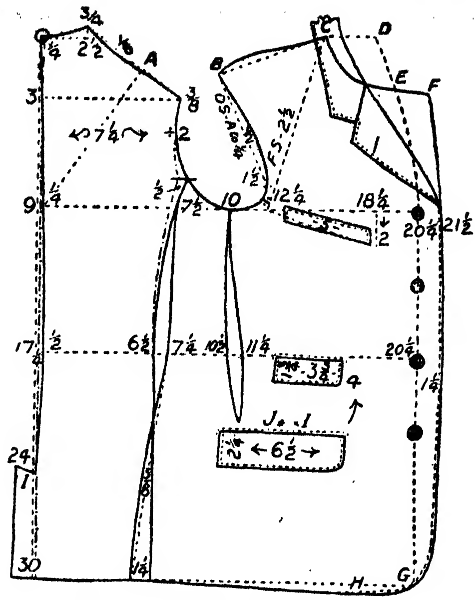
Make waist to measure plus 2 in. and so get 20¼; C to D, one-twelfth breast, less ½ in.; D to E the same amount, or to taste. Draw

breast line from D through E and 20¼ to G. Lengthen front at H ½ in. Add on 1¼ in. button stand for single-breasted, and 2½ in. to 3½ in. for double-breasted coat, and complete the front to taste.

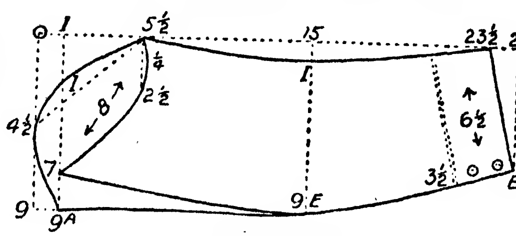
THE SLEEVE [18A]. Mark the pitches of the sleeve as follows:

Back 2 in. below ⅜. Front ¾ in. above 12¼. Draw lines at right angles to 0; 0 to 1, 1 in.; 1 to 5½, the distance from 2 to 7½ plus ½ in.; 1 to 9A, the size of the scye from 2 to ⅜ and B to front pitch taken straight; 0 to 4½, half 0 to 9. Draw line from 4½ to 5½ and add on ¾ in. to 1 in. of round. Shape sleeve head from 5½ and 4½ to 9A. Measure off the length of sleeve as taken less width of back, allowing for three seams (¾ in.), to 9E for the elbow and to B for the cuff. Hollow forearm at elbow 1 in. and shorten forearm seam at cuff 1½ in. Make width of elbow from 1 to 9E about one-sixth breast, plus 2 in., and width of cuff one-sixth breast, plus ½ in., or to taste.

For the underside sleeve, measure round the bottom of the scye, from back to front pitch, and apply the measure from 5½ to 7. Square from 5½ to 2½ one-third of this quantity, and hollow ¼ in. to ½ in.; curve up from 7, and continue from 7 to 9E. Complete sleeve as shown.



18. THREE-SEAM LOUNGE JACKET



18A. SLEEVE

VARIATIONS. For whole back mark in from 0, ½ in., and 30, ½ in., and draw back seam as per dot and dash line. For slit up bottom of back seam, leave on about 1 in. at I about 6 in. up. To omit the fish under the arm, take out ½ in. at the top of side seam as per dot and dash line, and allow a little more ease when measuring up the waist.

THE POCKETS. Hip pockets 4 in. below waist; 1 is midway between side seam and breast line; 1 to J is 1 in. Divide pocket flap on either side J; size of pocket same as width of sleeve at cuff. Depth about one-third of width. Ticket flap on waist front level with front of hip flap. Size of pocket usually about 3¾ by 1¾.

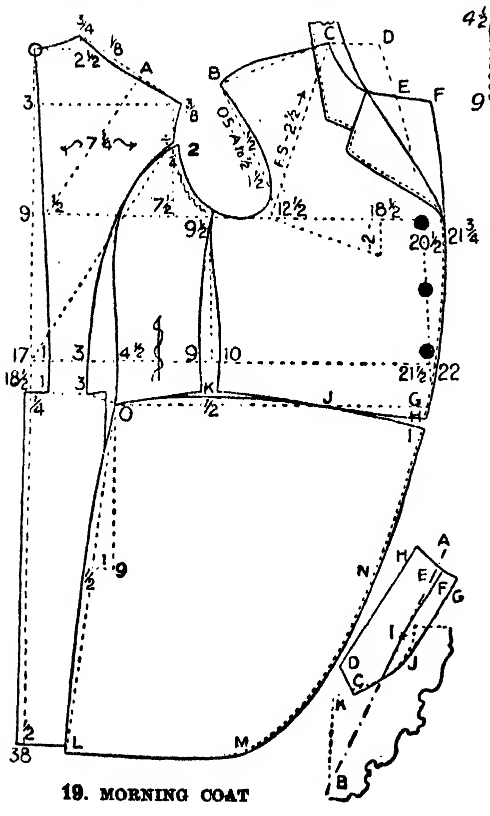
BREAST POCKET. Follow line 12¼ to 2, size about 5 by 1. Keep back end fully 1 in. in front of scye at 12¼.

Morning Coat. Shoulders same as Lounge [19]; 0 to 18½, fashion waist length; 0 to 38, full length, plus ½ in.; 17 to 1, 1 in.; Draw back seam, 0 to 1; 1 to 3, one-eighteenth breast.

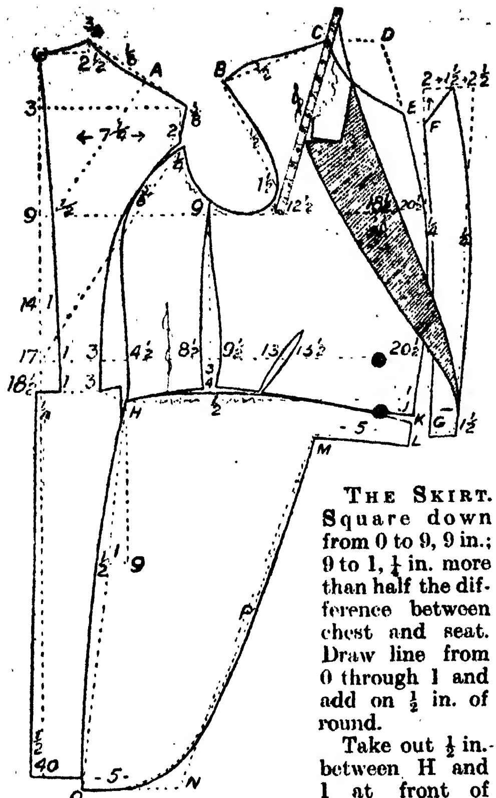
Width of back scye ⅜ to 2, the same as 1 to 3. Draw line from 2 to 17 and hollow ½ in. to ¾ in.

Draw side seam from ¼ to 3; 3 to 4½, 1½ in.

Take out ½ in. at 2. Make 2 a pivot, and sweep from 3 to 0; ½ to 9½ one-fourth breast; 9 to 10, 1 in. Make up waist to measure, plus 2 in. Hollow waist seam 1 in. at K, and drop it 1 in. at H. Add 1¼ in. button stand beyond breast line, and complete run of fronts to taste.



19. MORNING COAT



21. DRESS COAT

THE SKIRT. Square down from 0 to 9, 9 in.; 9 to 1, $\frac{1}{4}$ in. more than half the difference between chest and seat. Draw line from 0 through 1 and add on $\frac{1}{2}$ in. of round.

Take out $\frac{1}{2}$ in. between H and 1 at front of skirt, and $\frac{1}{4}$ in. at K. Shape the front of skirt, 1, N, M, and L to taste.

THE COLLAR. Dotted line indicates the neck of forepart. B is $\frac{1}{4}$ in. above top buttonhole. J to 1 is $\frac{1}{4}$ in. less than collar stand.

Draw line from B through 1 to E. E to G, the depth of fall. G to F, the depth of stand. F to H, the depth of fall. G is the width of back neck from fore part. Follow the neck from J to C, letting it overlap $\frac{1}{4}$ in at C. C to D to taste. B 1 F is the crease row.

Frock Coat. Similar to Morning Coat in body and shoulder parts up to the breast line D to 1, in the front of which add on $\frac{1}{2}$ in. at E; $\frac{1}{4}$ in. at F to nothing at 1 [20].

The lapel is drawn straight from O to G. 0 to 2, 2 in. 2 to $1\frac{1}{2}$, $1\frac{1}{2}$ in. 2 to $3\frac{1}{4}$, $3\frac{1}{4}$ in. Complete as shown.

THE SKIRT. I to J 2 to 3 in. J to L is a straight line from which square down to 9 9 in. 9 to 1, 1 in., or $\frac{1}{4}$ in. more than half difference between chest and seat.

Add on $\frac{1}{2}$ in. of round. O to P, $\frac{3}{4}$ in; draw waist seam from L through P to K. K is $\frac{1}{2}$ in. less than the width of lapel in front of J.

Drop down from L 2 in. to 3 in. to agree with H to J, and square K N at right angles. K to N the same length as L to M of back. This diagram shows the medium turn with the fronts buttoning three; a higher turn with the fronts buttoning four (this style should have the lapel hollowed at the top $\frac{3}{4}$ in.), and a low roll with the fronts buttoning two (this should have the lapel rounded $\frac{3}{4}$ in. in order to get a shorter outside edge).

Dress Coat. The shoulders and body parts are cut in the same way as the morning coat, with the following exceptions [21]. Point E on the front of neck is lower 1 to $1\frac{1}{4}$, so that D to E equals one-eighth breast. The waist between 1 and $20\frac{1}{2}$ is made up to half the waist measure only, making allowance for what is taken out between 3 to $4\frac{1}{2}$, $8\frac{1}{2}$ and $9\frac{1}{2}$, and 13 and $13\frac{1}{2}$.

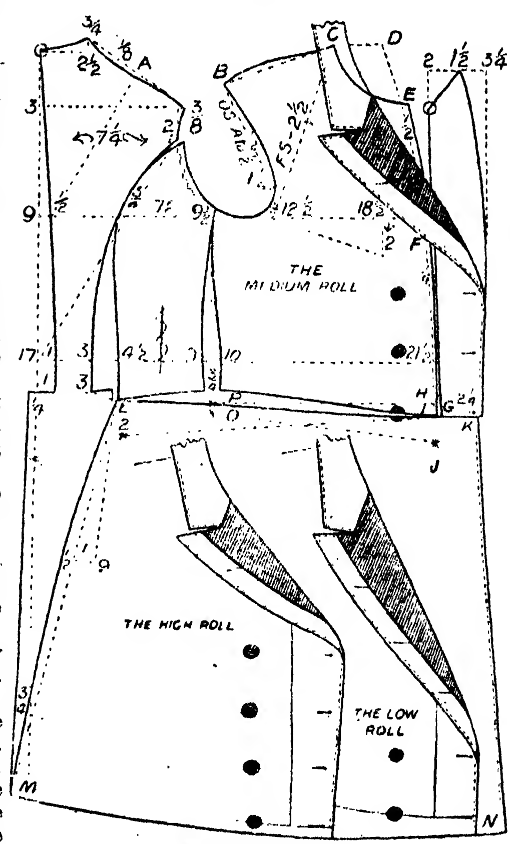
THE LAPEL. Draw a straight line and hollow $\frac{1}{4}$ in. to $\frac{1}{2}$ in. From F come up 2 in. and go forward $1\frac{1}{2}$ and $2\frac{1}{2}$. The length of the lapel should be sufficient to cover the bottom of the strap of skirt. Width of the lapel at bottom $1\frac{1}{2}$. Draw a line from $2\frac{1}{2}$ to $1\frac{1}{2}$ and add on $\frac{1}{4}$ in.

THE SKIRT. The back and top parts of skirt are the same as for the morning coat, the proportions of the other parts being as follows:

K to L, $1\frac{1}{2}$ in. L to M, one-third of the width of skirt at top. Q to N, one-third of the top. Draw line from M to N, add on a little round.

Sometimes the back is cut $\frac{1}{4}$ in. narrower all through with the view of making it lighter and smarter looking, but this is a matter of taste, and we have kept to the same style as the morning coat for the sake of simplicity.

Continued



20. FROCK COAT

PROFIT & LOSS & BALANCE SHEET

Subsidiary and Drawings Accounts. Expenses of Production and Distribution. Ranking Assets and Liabilities. Fixed and Floating Assets. Depreciation

Group 7
CLERKSHIP
19

Continued from page 2604

By J. F. G. PRICE

THE totals of the trial balance having been found to agree, the work of closing the books may now proceed. The object of our trader in preparing his final accounts is, as we have seen, to ascertain the nature and extent of his gains and losses, assets and liabilities. It should be observed that it is almost as important for a trader to know the nature of his gains and losses as to know their extent, for a knowledge of the manner in which they arise will enable him to push business in a direction where he finds he is already making good profits, or, on the other hand, to curtail expenses under heads which are not repaying the outlay upon them.

Division of Profit and Loss Account. It is largely for this reason that the profit and loss account has to-day so many divisions. It is not sufficient to know that although the gross profit of a business is £1,000, the net profit, after deducting an item described as "Sundry Trade Expenses," is £300 only. The modern business man wants further information. How is the difference of £700 made up? "Sundry Trade Expenses" may mean anything. The item may, and probably does, contain salaries, rent, rates and taxes, discounts allowed, gas, office cleaning, and the thousand-and-one petty items that go to swell the expenses of carrying on an office or warehouse. But let us know what they are, so that we can, if desirable, cut down expenditure in one direction and add to it in another, with a view to increasing the effectiveness of the outlay.

Heads of Expenditure. The heads over which the expenses are spread depend very largely upon the nature of the business, but some items are common to nearly all trading concerns. Salaries, rent, rates, taxes, lighting and heating, have to be paid in nearly every establishment. Other items, such as insurance, advertising, printing, discounts and commissions, are not so common, but are yet very frequently incurred. A close scrutiny of these items should enable a trader to form a conclusion whether his expenditure under a particular head is justified or not, having regard to the size of his business and the amount of his turnover. He may find that the amount he is paying for his rent, or for the salaries of his employees, is altogether out of proportion to his other expenses, and is practically swallowing all his profits. He must either reduce this expenditure if his sales are stationary, or increase the latter if he is to continue his expenditure at the same rate. On the other hand, he may find that a judicious outlay of £100 in advertising has caused an increase of £500 in his sales. This would probably lead him to conclude that further expenditure in this direction would result in extending his business, and he would act accordingly.

In the case of traders, as a rule the only item on the revenue side of the profit and loss account is the gross profit brought down from the trading account, arising from the sale of the goods. No analysis, therefore, is required for this side. In businesses where the revenue is of a miscellaneous nature, appropriate accounts are opened as in the case of expenses.

Method of Analysing. Enough has been said to show the necessity of analysing the expenses of the business in such a way that the proprietor can put his finger on a weak spot in his outgoings, or, on the other hand, satisfy himself that the expenditure is on an economical basis and allocated in such a manner as to produce the best results. But it is not necessary to wait until the profit and loss account has been completed before making the analysis. It can be made as the work of writing up the books proceeds throughout the year. In the case of the goods account it was seen to be desirable to have not one, but several, accounts to record our purchases and sales, and other matters directly connected with the buying or finishing of the goods. So, in the case of the profit and loss account, several sub-accounts are opened; and as sums are paid for expenses the payments are posted from the credit side of the cash book to the debit of the appropriate accounts opened in the ledger. The result will be that at the end of the financial year, instead of one large miscellaneous account containing expenses of all kinds, we shall have many smaller accounts, each devoted to an expense of a particular kind. The number of such accounts depends upon the size of the business, but a reference to the trial balance on page 2502 carries conviction of the superiority of this method of analysing the expenses rather than including them in one account under a general title.

Closing Subsidiary Accounts. In order to arrive at the amount of profit or loss as a whole, each item in the trial balance which records revenue or expenditure in carrying on the business must now be brought into a general profit and loss account. This must obviously be done, for the usefulness of the whole work will be destroyed if the accounts are not focussed in such a way as to give the trader a bird's-eye view of the items making up the profit or loss for the year. There is now no objection to the various heads of expenditure being included in one account, for they will not now consist of hundreds of small items in no kind of order, covering many pages of the ledger, but

of some twenty items at most, being the balances of the various sub-accounts already explained.

Those accounts are now closed by the balances being transferred to the profit and loss account by means of a journal entry debiting that account and crediting each sub-account of expenditure with the balance shown thereon. In the event of there being any source of revenue other than the sales, the accounts which have been credited by such revenue will be closed into the profit and loss account by a transfer of the balance being passed through the journal debiting the account and crediting profit and loss account.

Applying these principles to the trial balance on page 2502, and assuming the stock on hand to be worth £2,500, we should obtain the following as our trading and profit and loss account of the business of Smith & Jones:

Again, in a business part of an item of the same general character may be included in trading, and the rest in profit and loss. For example, the wages of the workmen would be a part of the cost of the finished goods, while the remuneration of the travellers and clerks would not. The wages would be charged to trading account, the remuneration to profit and loss account. The general principle to be observed is that cost of production is included in the first part of the trading and profit and loss account, while expenses of distribution come into the second part.

Disposal of Profit or Loss. The balance of profit or loss is not left on the account and brought down as the amount with which to begin the new trading period; that course is only adopted with the real and personal accounts. The profits of a business belong to

Dr. TRADING AND PROFIT AND LOSS ACCOUNT. Cr.

To Stock		1,750 0 0	By Sales	6,700 0 0	
,, Purchases ..	5,250 0 0		*Less* Returns Inwards	152 10 0	6,547 10 0
Less Returns Outwards	105 15 0	5,144 5 0	,, Stock on hand..		2,500 0 0
,, Wages		725 16 0			
,, Freight and Carriage		146 8 6			
,, Gross Profit carried down ..		1,281 0 6			
		9,047 10 0			9,047 10 0
To Salaries		357 10 0	By Gross Profit, b/d		1,281 0 6
,, Rent, Rates and Taxes ..		350 0 0			
,, Discounts ..		23 1 3			
,, Miscellaneous Trade Expenses.		109 16 2			
,, Balance, being Net Profit ..		440 13 1			
		£1,281 0 6			£1,281 0 6

It will be observed that the gross amount of the purchases and sales are stated in an inner column in which the returns are also entered and then deducted, the net amount of goods bought and sold being extended to the outer column. This is found to be convenient in practice, as affording at a glance the actual amount of purchases and sales for the year.

Production and Distribution. A question sometimes arises whether a particular item of expenditure should be charged to the trading or to the profit and loss account. The decision will to some extent depend upon the character of the business, for items which in one case would be debited to the trading account would in another case be charged to the profit and loss section. For instance, in an ironfounder's business coal would be largely used in producing the finished article, and would be part of the cost thereof. In that case the outlay on coals would be charged to trading account, while in the case of a business where coal is only used for ordinary heating purposes it would be charged to profit and loss, as the expenditure forms no part of the cost of the goods sold.

the proprietor, or, if there be more than one, to the partners in the concern, and the balance of profit as shown by the account must be transferred to their accounts by means of a journal entry debiting profit and loss, and crediting them. The proportion to be credited to each partner depends upon the terms of the agreement between them as to sharing profits and losses. This agreement contains many provisions besides that dealing with this point, and will be explained at greater length when the question of partnership accounts as a whole are receiving consideration.

It should be mentioned here, however, that the amounts are not carried direct to the credit of the partners on their capital accounts, but are taken to their respective *drawings accounts*. These are accounts opened in the name of each partner for the purpose of recording amounts drawn by them from the business during the year on account of their shares of profits, which, of course, are not definitely known until the final accounts are made up. The drawings are usually in the form of cash, the payments being recorded in the cash book and posted to the debit of the accounts as the money is drawn.

If, as sometimes happens, a partner has goods from the business for his private use, he is charged with the price in the same way as an ordinary customer, the amount being posted from the day book to the debit of his drawings account.

Closing the Drawings Accounts. When the books are closed at the end of the firm's financial year, the balances of the drawings accounts are transferred by journal entries to the credit of the several partners' capital accounts. In the particular case with which we are dealing we will assume that the partners jointly manage the business, and, their capitals being the same, the profits or losses are shared equally. They will therefore be entitled to £220 6s. 6½d. each, but, as fractions of a penny are not regarded in accounts of this nature, a journal entry will be made, debiting profit and loss account, and crediting Smith's drawing account with £220 6s. 7d. A similar entry will be passed crediting Jones's drawing account with £220 6s. 6d. Their drawing accounts will thus show balances of £70 6s. 7d. and £70 6s. 6d., and these will be transferred to their respective capital accounts, increasing the credit balances thereof by the amounts so transferred. The accounts are variously styled drawing, private, or current accounts in different businesses, but by whichever name they are known they contain in every case particulars of the same nature and are dealt with as described. Any overdrawing of his ascertained share of profit by a partner will be carried to the debt of the partner's capital account, thus reducing the amount of his capital; but it is not unusual for a partner to pay into the business any excess of this nature, so that his capital account shall not be disturbed.

The Balance Sheet. Having now dealt with those accounts in the trial balance affecting profit and loss, and transferred the balance ascertained (being the net profit) to the partners' accounts, we proceed to dispose of the remaining accounts. Upon examination these will be found to consist of property belonging to the business, including debts owing by customers, or of amounts owing by the business; in other words, of assets and liabilities. These have now to be arranged in the form of a statement in such a manner that the partners can see at a glance what is the nature and extent of the assets and liabilities.

The method by which this is effected is by dividing the statement into two parts, one for assets, the other for liabilities. But before making up the statement—or, as it is called, the balance sheet—it is necessary to balance the accounts in the ledger from which it is compiled. This is done by writing in the amount of the balance on each account on the smaller side, then totalling and ruling off the account and carrying down the balance to the opposite side from that on which it was first entered. No journal entries need be made for these items, as they do not consist of transfer from one account to another. Those accounts which have the same amounts entered on each side without the inclusion of a balancing entry are ruled off, and the totals inserted. Having taken this necessary step, we can now construct our final balance sheet, thus:

BALANCE SHEET, 31st DECEMBER, 1905.

Liabilities.			Assets		
Sundry Creditors:			Cash at Bank ..	414 3 2	
F. White	205 12 10		do. in hand ..	12 18 6	
					427 1 8
S. Grey	164 9 11		Sundry Debtors:		
		370 2 9	A. Black	200 19 6	
Capital Accounts:			G. Brown ..	196 11 7	
			W. Green ..	186 3 1	
Smith	1,570 6 7				583 14 2
Jones	1,570 6 6	3,140 13 1	Stock of goods on hand		2,500 0 0
		3,510 15 10			3,510 15 10

The difference between the assets and the liabilities to outside creditors must always equal the balances of the proprietors' capital accounts.

Grouping of Accounts. The first thing to be noticed in connection with this balance sheet is that items of a similar nature are first entered in an inner column, and their total extended to an outer column. This is to enable the proprietor of a business to see at once the amount of his property of a particular description or the extent of his liabilities under a certain head. In the specimen given the only classes of accounts, besides the capital accounts, in which there is more than one item, are the sundry debtors and creditors; but in some businesses the main classes of assets and liabilities are subdivided under several heads, and this renders it necessary to group the various items under their proper headings in the balance sheet, in order that a correct idea of the nature of the property and liabilities may be formed. This feature of the balance sheet is obvious to the most casual observer, but there is a further point which would not be so apparent to a person unfamiliar with such documents and the principles of their construction—that is, the order in which the accounts are set out.

Ranking the Assets. This is an observance of the principle that the accounts should enable the trader to ascertain not only the extent, but also the nature, of his assets and liabilities. The order in which the assets should be ranked is well settled on broad lines, but in some businesses there are classes of assets practically on the same level as one another,

and as to which there may be legitimate difference of opinion regarding their order of priority. These are, however, unimportant. The guiding principle to be observed is that the assets should be ranked in the order in which they are most readily available for realisation. Following this rule, the assets should be arranged in the following order:

1. Cash. In many businesses this appears in various forms: (*a*) cash at bank on ordinary current account—*i.e.*, paid in and drawn upon by cheque daily; (*b*) general cash (if any) in the office; (*c*) petty cash in the hands of the petty cash officer; (*d*) cash at bank on deposit in respect of which it may be necessary to give the bank notice of withdrawal before it can be obtained.

2. Investments belonging to the business. In trading concerns it is not often that the cash capital is used for the purpose of buying securities. It can be more profitably employed in the purchase of goods of the description sold by the business. If, however, there should be any investments, it is desirable to specify them.

3. Sundry debtors. These are frequently divided into two classes—those who have given bills for the amount of their indebtedness, and those who have not. The former appear under the head of bills receivable; the latter under sundry debtors on open accounts, which are those showing a balance due for which the business has received no payment of any kind. The totals of the two classes appear first in the inner column, and are then extended into the outer column as one item.

4. The stocks of goods belonging to the business. These will consist of the stock actually on the premises, and of any items that may be in the hands of other persons, either for sale on commission (consignments) or on approval.

5. Movable property of a less easily realisable nature than those given above, consisting of (*a*) plant and machinery; (*b*) horses and carts; (*c*) fixtures, fittings, and furniture; (*d*) patent rights.

6. Immovable property—including (*a*) freehold land and buildings, and (*b*) leasehold premises.

7. Goodwill.

Ranking the Liabilities. On the other side of the balance sheet also it is necessary to have a systematic arrangement of the items. There are liabilities of various kinds, and the order to be observed in arranging them is, in an ordinary business, as under:

1. Any liabilities for which security has been given, such as mortgages or an over-draft at the bank.

2. Sundry trade creditors, distinguishing between those who hold bills payable and those on open accounts.

3. Any reserve accounts which may have been created. (These will be explained later.)

4. The capital accounts of the proprietors.

The rule to be followed in arranging the liabilities is to state first those to persons outside the business, and then other liabilities, such as that of the business to the proprietor for the amount of his capital.

Floating Assets. The assets set out above may be divided into two classes:

(1) Those constantly changing in character.
(2) Those which do not so change, but remain in the same condition throughout (subject to wear and tear).

The first four items will be included in class 1, and are known as floating assets. A study of the items will, in a measure, explain this description. The cash, debts, and stock are constantly changing hands, while their value is continually fluctuating as between themselves, and, if the business is successful, also increasing. That they change in character and increase in amount will be evident if we consider the various steps in connection with a purchase of goods.

An order for goods is given by our trader. The goods arrive and are taken into stock, thereby increasing that item. They are then paid for, the result being a diminution of the bank balance. In course of time they are sold, thus reducing the stock and increasing the book debts. Subsequently the debtor may discharge his liability by giving a bill, thereby adding to the value of bills receivable and reducing the open book debts. Later, the bill is met at maturity, and increases the bank balance. The net result should be an augmentation of the cash in the bank, for naturally our trader will not have sold the goods for less than he gave for them.

Fixed Assets. The remaining assets, on the other hand, may be said to be permanent. They are used over and over again in the making or handling of the goods. In an ordinary trading concern the premises, plant, machinery, fixtures and furniture are used daily in carrying on the business, which, indeed, could not be continued without them. A manufacturer uses his machinery—his fixed asset—to transform his raw material—his floating asset—into the finished article. And this not once, but many times. The machinery has not changed in form in any way, but the transformation of the raw material into the finished piece is another illustration of the manner in which the floating assets change in character and value, for the manufactured goods will naturally be worth more than the raw material of which they are made. To summarise the matter, it may be said that the fixed assets are those which are continually used to earn income for the proprietor.

It should be noticed that an item which in one business is a fixed asset, may in another be ranked as a floating asset. For instance, machinery employed in a printing establishment would be a fixed asset, while in the case of a maker of machinery it would be part of his stock, and therefore one of his floating assets.

Depreciation of Assets. A passing reference has been made to wear and tear of the fixed assets, and mention has also been made of the depreciation of the stock of goods in the hands of a trader. These are matters which engage the serious attention of the accountant when preparing the final accounts, for unless

due allowance is made under these heads before determining what is the net profit of a business, the result obtained is misleading and may involve grave consequences. Practically every asset of a business, with the exception of cash, is subject to depreciation of one kind or another. The rate or amount is not, however, by any means fixed.

The depreciation of stock-in-trade has received some consideration, and it will be sufficient to state that as a general rule stock should fall very little in value.

Wastage of Fixed Assets. It is chiefly in connection with assets of a permanent nature that care has to be taken to make proper provision for decrease in value. In a manufacturing business, for example, the wear and tear of the machinery is as much a part of the cost of the manufactured articles as is the cost of the raw materials and the labour put into them. The measure of the cost under this head is the difference between the price of the machine and its present value. The latter could only be ascertained by calling in an expert to make a valuation. This is not found convenient in practice, besides being costly, and another method of arriving at the amount of loss to be charged is adopted. A manufacturer knows by experience, or can ascertain from the maker, the probable duration of the machine. The number of years for which it can be used is divided into the cost price, and the amount thus obtained is charged each year in the profit and loss account as an expense of the business. There are more scientific methods of arriving at the amount which should be charged or written off, but they can be dealt with more appropriately later.

Possibility of Obsolescence. Besides wear and tear to the machine there is a further matter to be considered when dealing with an asset of this nature. Human ingenuity is constantly devising new and improved methods of manufacture in practically all industries, and this factor should be taken into consideration when forming an opinion as to the period for which the machine will be valuable. For in the event of a new machine being placed on the market of such a nature as to render it impossible for the manufacturer to continue his present methods owing to the adoption by his rivals of the cheaper or quicker system, he would have to regard his machine as obsolete and put himself on an equality with them by installing one of the latest pattern.

From these remarks it will be seen that there are elements which render it impossible to place absolute reliance upon the estimate formed, however carefully it may have been made. The utmost that can be done is to take into consideration every contingency that can be foreseen and form a conclusion upon those premises.

The remarks upon the question of wear and tear apply to the other fixed assets mentioned on the preceding page, save only the freehold land and the goodwill, for it is clear that neither horses nor carts improve with age, and that if the business has had the benefit of their services it must not only be charged with the wages of the carmen and the forage and stabling of the horses, but also with the decrease in value which has taken place in consequence of their being used for the purposes of the business. Fixtures stand in the same position as machinery, and the decrease in their value must form a charge likewise.

Patent Rights. Patent rights stand upon rather a different footing. Patents are granted for a period of fourteen years, during which the patentee has the sole right of using the invention forming the subject of the patent. At the end of that time the general public will be at liberty to use the invention and, as an asset, the invention will have disappeared, subject to any value there may be in the goodwill which may have been built up by the patentee as sole maker during the existence of the patent. With this reservation, therefore, the patentee has to contemplate the certain loss of a particular asset within a known period, and he should take steps to extinguish the book value by writing off a proportion each year as depreciation. The same course should be adopted with the book value of leasehold premises, the amount written off depending principally upon the number of years the lease has to run.

The only remaining item in our list is goodwill. Except in the case of a steadily losing business this cannot be said to depreciate regularly. It may fluctuate with the rise and fall of the profits of a business, but it should rarely be appreciated in the books, and is, on the contrary, frequently written down either directly or indirectly by means of a reserve, which need not be explained here but will be considered later.

Method of Recording Depreciation. The manner in which the operations described are performed is to debit profit and loss account, and credit the particular asset to be depreciated. The debit to profit and loss is not, however, entered direct on that account. A depreciation account is opened and debited with the several items to be charged in respect of the various assets, the journal entry being made as follows:

Depreciation	Dr.	368	
To Machinery			200
„ Horses and Carts			75
„ Fittings			25
„ Patent			68

being the amounts to be written off for depreciation during the year as agreed by partners.

The depreciation account will be closed by transferring the balance to the debit of the profit and loss account by a journal entry.

It only remains to be said that in the case of the fixed assets the depreciation written off is shown in the inner column of the balance sheet as a deduction from the book value before the amount was charged, the net amount being extended.

Continued

STABILITY OF ARCHES

Thrust Lines. Straight Arch. External Loads. Curve of Thrust. Minimum Depth of Arch Ring. Concentrated Loads. Suspended Chains

By Professor HENRY ADAMS

The Thrust of an Arch. The thrust of an arch is the first and most important point for consideration. In **226** is shown the half elevation of an arch, where AB is the half span and BC the rise, DC the depth of arch at the crown, and EA the depth of arch at the springing or abutment. In small arches the spandrel EFGD is generally filled up solid, either by brickwork or masonry; or, in the case of a bridge, by the material of which the roadway is formed, so that while the arch itself is included within the outline AEDC, the load carried by the arch is included in the outline AEFGDC, omitting for the present the consideration of any external load. It is usual to consider the stability of 1 ft. run, the same as with walls; in this case it will be the same as if the elevation shown were 1 ft. thick. The centre of gravity of this figure must be determined by marking the outline upon drawing paper, cutting it out, suspending it consecutively from two points, and marking vertical lines to intersect, giving the point *c. g.* (centre of gravity). Its area must also be determined by planimeter or otherwise, as a measure of its weight. Then a vertical line must be dropped from the centre of gravity and a horizontal line drawn from the centre of the depth of the arch to meet this vertical, to give the intersection from which the weight of half the arch complete must be set off to scale downwards, and from which an inclined line must be drawn through the centre of the skew-back. Then the parallelogram of forces is completed by drawing from the bottom of the vertical line a horizontal line to meet the line of thrust through the skewback, and another inclined line upwards, parallel to the first inclined line. Then the length of the lines of the parallelogram marked H and T give respectively the thrusts to balance the load W. The thrusts being obtained, the required depth of arch ring may be calculated according to the strength of the material, and, if necessary, the increased thrust at the skewback may be met by increasing the depth of the arch towards the abutments. In brick arches this is sometimes done by increasing the number of arch rings towards the ends, as in **227**, and in stone arches by increasing the depth of the voussoirs as in **228**.

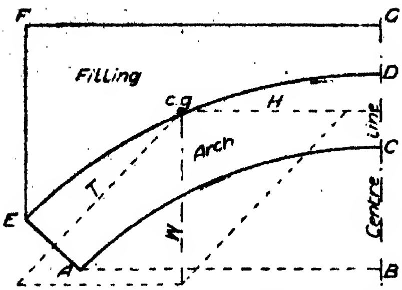
Straight Arch. A straight arch, such as the gauged arch over a window, is considered by some not to be an arch at all; but if the conditions be investigated, it will be found that it virtually contains an arch ring half the depth of the straight arch, and with a rise of the same amount, as shown by the dotted lines in **229**. This will also show that the angle of the skewback should be such as to lie in a radial line from the centre from which this virtual arch is struck, so as to be perpendicular to the thrust.

Forces Acting on a Voussoir. The forces acting upon a voussoir or arch stone are shown in **230**. The thrust T, from the next higher voussoir, is combined with the weight of and upon the present voussoir to give a new thrust to carry forward to the next lower voussoir. The angle θ must always be less than the limiting angle of resistance, or sliding will occur, and the thrust line must be within the middle third, in order that the effect may be one of pure compression.

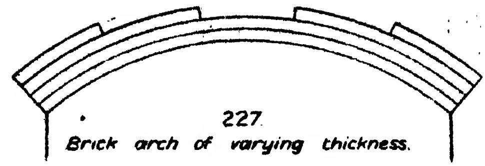
External Load on a Bridge. The external load on a bridge due to the traffic may be taken as 2 cwt. to 5 cwt. per foot super., according to circumstances, and added to the diagram, as if it formed part of the dead load of the structure, as shown by the upper portion in **231**. The main thrusts will then be found as before, including this load, and it is usual to show the curve of thrust throughout the whole of the arch. This is done by dividing up the arch into assumed voussoirs and producing vertical lines up to the top; then, locating the centre of gravity of each portion, and dropping vertical lines to represent force lines due to the weights, these weights will be set down in order on the reciprocal diagram **232**, the figures corresponding as in the usual method of drawing the load line on reciprocal diagrams. The horizontal distance [1—0] will then, upon the same scale, be made equal to the horizontal thrust at the crown and vectors, drawn from point 0 to the divisions on the load line, and parallel to these the curve of thrust will be drawn piecemeal across the spaces in **231**, as in the case of an ordinary funicular polygon. For stability, this curve of thrust should preferably keep within the middle third, but if at any point it comes nearer to the intrados or extrados of the arch ring, the pressure on the joint will be greater, but not necessarily too great for safety.

Curve of Thrust. It should be understood that the curve of thrust does not indicate that the pressure is concentrated along that line alone; the line merely shows where the centre of pressure cuts each joint, the resistance being spread over the whole surface of the joint, exactly in the same way as the resistance at the base of a retaining wall is proportioned over the surface of the base, according to the position of the resultant.

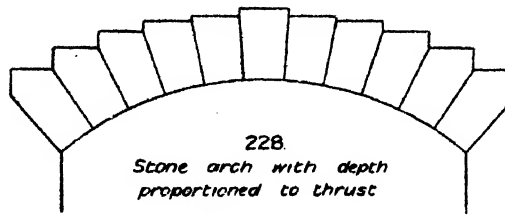
Minimum Depth of Arch Ring. It is a curious fact that there is a minimum depth of arch ring, according to the span and rise of the arch, independent altogether of the load upon it.



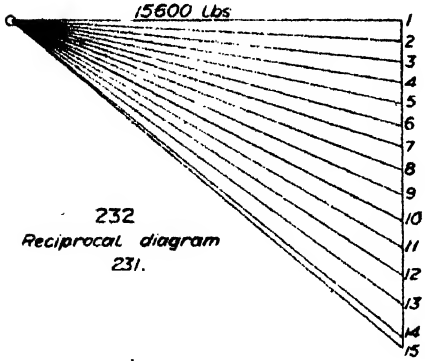
226 Principle of thrust in arch



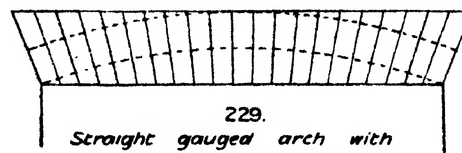
227. Brick arch of varying thickness.



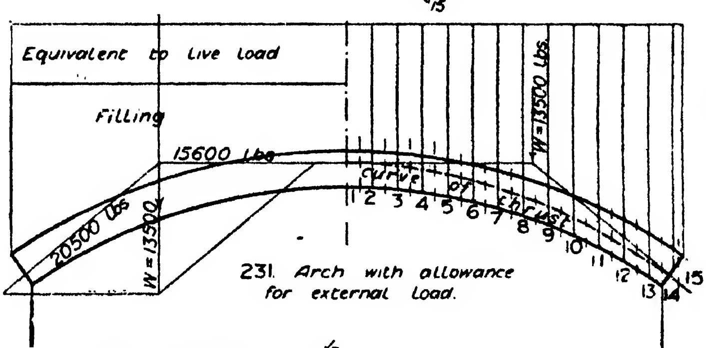
228. Stone arch with depth proportioned to thrust



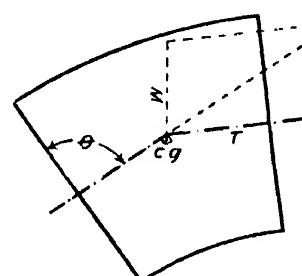
232 Reciprocal diagram 231.



229. Straight gauged arch with virtual arch dotted.

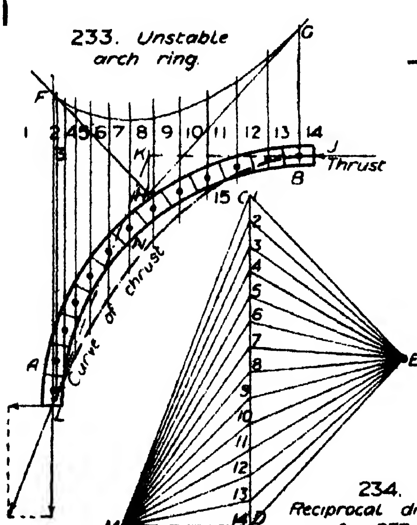


231. Arch with allowance for external load.

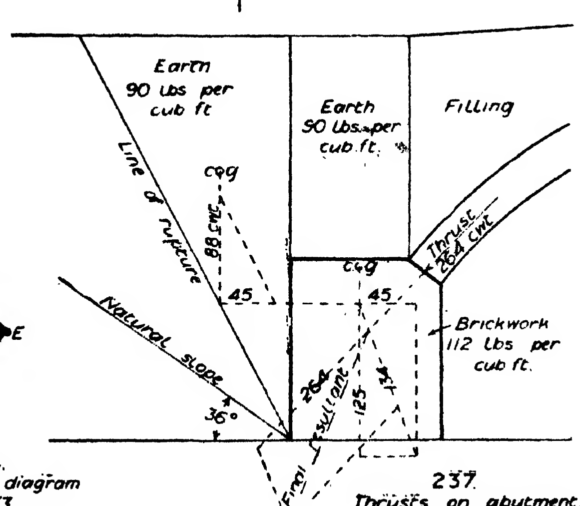


230. Forces acting on a voussoir

233. Unstable arch ring.



234. Reciprocal diagram for 233.



237. Thrusts on abutment.

STABILITY OF ARCHES

This arises from the necessity of keeping the curve of thrust sufficiently within the arch ring. A covering arch, 10 ft. span, formed of one ring of brickwork 4½ in. thick, set in cement, was built over a tank and had to carry its own weight only. Before the centering was removed, the arch bulged at the sides, about halfway between the springing and the centre, and when the centering was removed, the arch collapsed altogether. The reason will be seen by observing the position of the curve of thrust as shown in **233**, which is constructed from the reciprocal diagram **234**.

The lettering of the illustration shows the order of construction. AB in **233** is the half elevation of the arch, which is divided up not into the actual bricks, but into convenient portions for the method of working. Draw a vertical line through the centre of gravity of each portion, representing the direction in which its weight acts. Number the spaces between these force lines and draw the line of loads CD [**234**]. Select any pole E, and draw vectors to CD. From any point F on line 1—2 of **233** and across space 2 draw a line parallel with the vector from 2 in **234**. Continue across all the other spaces with lines parallel to the vectors, finishing at G. Now draw lines from F and G parallel with the vectors 1 and 14, to meet at H. From J draw a horizontal line through the centre of the arch to meet a vertical line from H at point K; join KL at the centre of the skewback, and produce to give the resultant. Now in **234** draw DM parallel to JK—that is, horizontal—and CM parallel to KL. Join all points on CD with M 15, then these lines will represent the thrust throughout the arch. The "curve of thrust" N is found as follows: from point L across space 2 draw a line parallel with 15—2, then continue across space 3, parallel to 15—3, and so on, until B is reached. For the arch to be stable without tension on any part this curve should be everywhere within the thickness of the arch ring. If the arch be made to the same curve as the line of thrust, the arch will, of course, be under the best conditions of stability, provided that in finding the line of thrust all the circumstances, such as accidental load, wind, etc., have been taken into account.

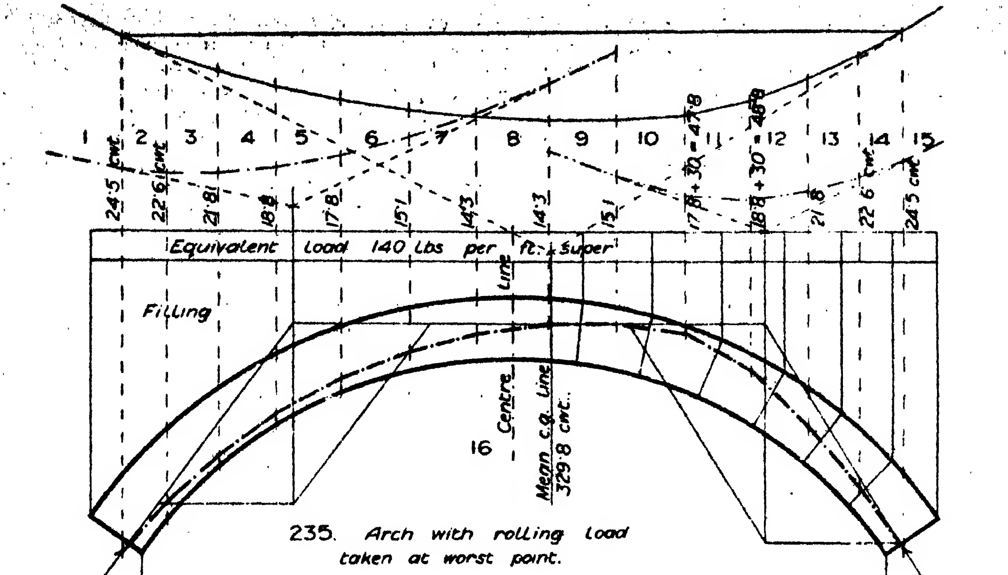
Thrust from Semicircular Arch. It is another fallacy to suppose, as many do, that there is no outward thrust from a semicircular arch. Whatever the horizontal thrust may be at the crown, there is a similar horizontal equivalent on each side acting outwards. An illustration of this occurs in **233**, where the inclined thrust at the skewbacks may be resolved into the two directions, vertical and horizontal, when it will be found that the horizontal component is equal to the horizontal thrust at the crown. It is a law of nature that the line of thrust takes the shortest possible course from the load to the support, so that if an arch ring be assumed to have no weight the thrust from a concentrated load on the centre would pass in straight lines to the skewbacks; and where a distributed load is carried, the horizontal thrust at the crown is depressed by the load it meets as it passes each joint towards the skewback.

Concentrated Loads on Arches. A concentrated load upon an arched bridge, as from the wheels of a steam roller or traction engine, produces a great distortion of the curve of thrust as the load passes over the haunches. Such a case is shown in **235**. The load tends to spread outwards in all directions in passing downwards to the arch ring, but it will be sufficient to consider it as spread over a distance about equal to the depth from the road surface to the arch ring, or even over one or two voussoirs. After dividing up the arch into the actual or assumed voussoirs, and finding the weight above each, the position of the vertical through the mean centre of gravity of all the loads, including the concentrated load, should be found by funicular polygon as shown, and then the mean centre of gravity line for each half. The previous descriptions will enable the method of constructing the reciprocal diagram **236** to be readily understood.

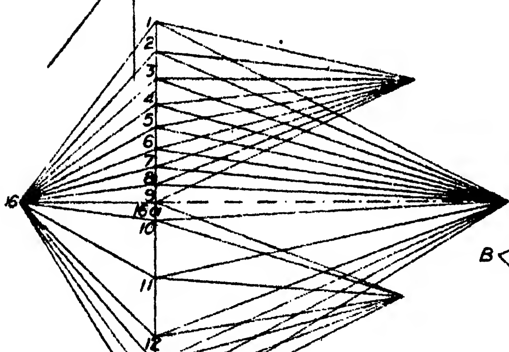
Is a Keystone Necessary? It is a common error to suppose that a keystone is necessary for the stability of an arch; it is purely a matter of taste, and the fact that countless thousands of brick arches exist without a keystone ought to be a sufficient answer to the holders of the idea that it is necessary. In the fronts of buildings the arches are often finished with a keystone or similarly-shaped block of gauged brickwork, but this is for the sake of appearance only.

Stability of Abutments. The abutment of a bridge is generally filled in with earth at the back, and this to some extent resists the thrust of an arch and reduces the necessary thickness. The wing walls of the bridge are continuous with the face of the arch, either in the same plane or at right angles to it, or at some intermediate angle. When curved wing walls are adopted they may commence in the same plane as the face of the arch and terminate at right angles to it. The wing walls give great support to the abutments, but they do not often enter into the calculations. Buttress walls may also be placed at intervals between the wing walls to give support to the abutments, and permit of a reduction in their thickness. A plain abutment without buttresses is shown in **237**. Plain abutments usually stop at or shortly above the skewback, and are then covered by the filling as in this case. To ascertain the stability, the mean centre of gravity of the abutment wall and the earth above it is found, and this weight is combined with the thrust of the earth, then the resultant is combined with the thrust of the arch, and the position of the final resultant with regard to the base of abutment together with the value of its vertical component determines the maximum pressure upon the base.

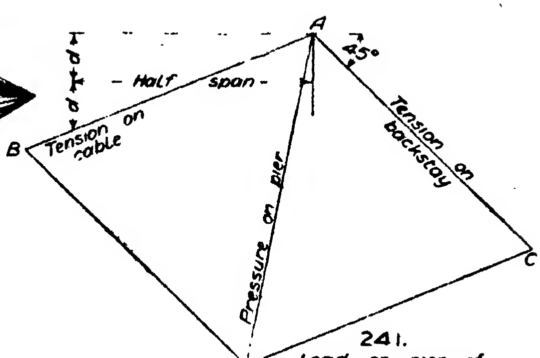
Stop Abutments. In the case of railway viaducts of several arches, the thrust of one is counteracted by the thrust of the next, so that the abutment or pier between has only the direct weight of the superstructure to carry. If, however, by fire or other accident one arch should fail, all the rest would fall by reason of the unsupported thrust. To prevent this it is



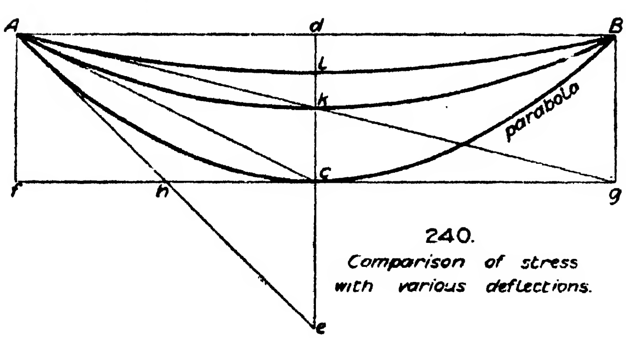
235. Arch with rolling load taken at worst point.



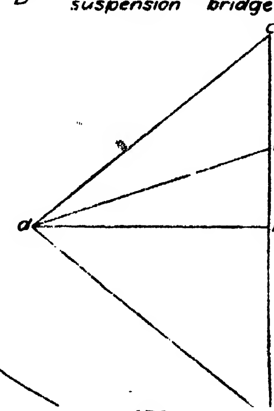
236
Reciprocal diagram for 235



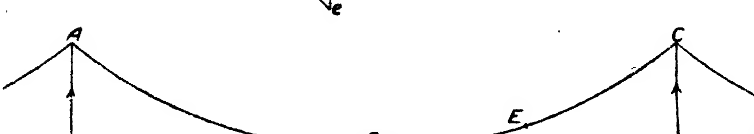
241.
Load on pier of suspension bridge



240.
Comparison of stress with various deflections.



239.
Reciprocal diagram for 238.



238.
Suspension bridge chain

STRESSES IN ARCH AND SUSPENSION CHAINS

usual to put a stop abutment at every tenth arch, so as to confine any such accident within those limits. The stop abutment is made sufficiently strong to withstand the thrust of an arch or of a series of arches if the next one should fail.

Suspension Bridge Chains. The chains for a suspension bridge take the same shape as the curve of thrust of an ordinary arch, but inverted. If the load be taken as approximately uniform over the span the curve will be a parabola, and this is generally the case owing to the excessive weight of the roadway compared with the chains themselves. Moreover, the catenary curve, which is the true shape of a suspended chain, is indistinguishable from a parabola when its dip does not exceed one-tenth of the span. When deeper, the catenary is seen to be nearer to the shape of a circular arc. The catenary is also a difficult curve to draw, while the parabola is very easy.

Stresses in Suspension Chain. The stresses in a suspension chain can be shown very readily by a graphic diagram. Let ABC [**238**] represent the elevation of a suspension chain uniformly loaded throughout the span with a total load AC, then by reciprocal diagram let *ac* [**239**] equal the line of loads, draw *ad*, *cd*, parallel to tangents to the chain at A and C, then the lengths *ad*, *cd*, will give the stress at points A and C. Similarly, *db* parallel to tangent at B, or *de* parallel to tangent at E, will give the stresses at those points. Allowance may be made for any want of uniformity in the actual loading by setting off upon the load line of the reciprocal diagram the load to be carried at each of the points of attachment.

Effect of Dip in Chain. The effect of reducing the dip or deflection of the chain in increasing the stress may be shown comparatively by diagram **240**, where AB is the span and *dc* the deflection. Then, according to the rule for a parabola, make *ce* equal to *dc*, and join A*e* to give the direction of the tangent to the curve at point A. Complete the enclosing parallelogram AB*fg*, then A*h*, being the tangent, A*f* : load on A*c* : : *f h* : stress at *c*, or stress at $c =$ load on A$c \times \frac{fh}{Af}$. Take point *k* so that *dk* equals half *dc*, then A*c*, being the tangent, A*f* : load on A*c* : : *fc* : stress at *k*, or stress at $k =$ load on A$c \times \frac{cf}{Af}$. Again, take point *l* so that *dl* equals half *dk*, then A*g*, being the tangent, A*f* : load on A*c* : : *fg* : stress at *l*, or stress at $l =$ load on A$c \times \frac{fg}{Af}$, from which it will be seen that the general statement may be made of *half the dip, double the stress.*

Stress by Calculation. The tension at the lowest point of the cable follows the same law as the flange stress in the centre of a girder, or the thrust at the centre of an arch—*viz.*, $T = \frac{Wl}{8d}$, where T = tensile stress in tons, W = total load in tons, l = span in feet, and d = dip in feet. The tension at the piers will manifestly be increased by the weight of the chain being suspended from those points. The amount of the tension in the cable at the piers will be given by the formula

$$T = \sqrt{\left(\frac{Wl}{8d}\right)^2 + \left(\frac{W}{2}\right)^2}$$

Tension in Backstay and Pressure on Pier. The tension in the backstay, or anchor chain, and the pressure on the pier will depend upon the angle at which the former leaves the pier. If it is curved, then the tangent to the curve must be taken as the virtual direction. An illustration is shown in **241**. Let A be the top of pier, set off half the span of suspension chain to any scale and at the end set off twice the dip to the same scale, and through the point so found draw line AB, which will be the tangent. Let AB equal the tension to any given scale, then, if the cable is free to move over the piers, the tension will be of the same amount in the backstay, therefore draw AC equal to AB, and let AC follow the direction of the tangent to the backstay. Then complete the parallelogram BACD and draw the diagonal, which will give by its length the resultant pressure and its direction upon the pier.

Books for Students. Processes alter so rapidly nowadays that books on materials soon become deficient, still remaining useful, but requiring supplementing by reference to the current technical press. Rivington's "Notes on Building Construction," Vol. III. (Longmans, 21s.) will be found to contain a mass of information upon all kinds of builders' materials. Another useful book is Middleton's "Building Materials: Their Nature, Properties and Manufacture" (Batsford, 10s. net). To these should be added Sexton's "Chemistry of Materials of Engineering" (Technical Publishing Co., 5s.). There are in addition many books on special branches for which catalogues should be consulted. For the strength and testing of materials such works should be consulted as Popplewell's "Testing and Strength of Materials of Construction" (Scientific Publishing Co., 12s. 6d.) Unwin's "On Testing Materials" (Longmans, 16s. net), Burr's "Elasticity and Resistance of the Materials of Engineering" (Wiley & Sons, 30s.), Box's "Strength of Materials" (Spon, 12s. 6d. net). For an introduction to graphic statics, Adams' "Strains in Ironwork" (Spon, 5s.), Hardy's "Elementary Graphic Statics" (Batsford, 3s. net); and for advanced work, Goodman's "Mechanics Applied to Engineering" (Longmans, 9s. net). For stability of structures, Patton's "Treatise on Civil Engineering" (Chapman & Hall, 31s. 6d.), Rankine's "Civil Engineering" (Griffin & Co., 16s.), Anglin's "Design of Structures" (Griffin & Co., 16s.), Adams' "The Practical Designing of Structural Ironwork," first series (Spon, 8s. 6d.); "Designing Ironwork," second series (Spon, Part I., 1s. 6d.; Part II., 2s. 6d; Part III., 2s.; Part IV., 2s.), Fidler's "Bridge Construction" (Griffin & Co., 30s.).

Materials and Structures concluded

continued from page 2576

THE REVENUE DEPARTMENTS

Surveyors of Taxes. Estate Duty Clerks. Port Service Clerks. Customs Officers. Excise Officers. The Government Laboratory

By ERNEST A. CARR

NO more interesting duties are comprised in the service of the State than those which relate to the safeguarding of the vast revenues derived from taxation. These functions are entrusted to the two great departments of the Inland Revenue and the Customs.

Inland Revenue and Customs. The former is concerned with the income arising from internal sources, such as stamp duties, taxation upon legacies and estates, trading and other licences, and the duties payable in respect of the manufacture of beer and spirits. Customs work, on the other hand, is mainly the enforcement of taxes upon imports, including the prevention of smuggling. It will be readily understood that the two branches have much in common; and, indeed, proposals for their amalgamation into a single huge revenue department have been urged from time to time, but hitherto without success.

A characteristic feature of each service is that, in addition to a large clerical staff, it employs a great many executive officers, whose duties, while often arduous, afford plenty of variety and interest, and for the most part are performed in the open air. This outdoor staff, instead of being restricted to London like the majority of national servants, is scattered throughout the Kingdom and is subject to frequent transference from district to district. Hence, the executive service of the Customs and Inland Revenue attracts every year a number of hardy young fellows who prefer hard work, irregular hours, and change of surroundings to the monotony and restraint of a life spent at a London desk.

Clerks in the Revenue Service. The Inland Revenue Offices are largely maintained by members of the general staff of Government clerks, whose positions have already been discussed in the two preceding articles. The only special indoor grades that call for notice here are those of Surveyor of Taxes and Estate Duty Clerk. The Customs indoor work, both central and local, is performed by departmental officers known as clerks for port service. We may conveniently deal with those three clerical ranks in turn before passing to consider the outdoor staff.

Assistant Surveyorships of Taxes. This service is recruited by means of open competitions held in January or February of each year. The work is heavy, but the appointments are fairly valuable ones; and as a good many posts—usually from a dozen to twice that number—are offered annually, they merit the attention of candidates who have received a good general education and are not daunted by the prospect of a few special subjects in addition.

The limits of age are 19 and 22, and the examination fee is £6. Competitors are examined in each of these subjects: English composition, arithmetic, accountancy (with bookkeeping by double entry), political economy, and the law of evidence. They may also take three subjects in the following list, including not more than two languages: Latin, French, German, geometry (Euclid, Books I. to IV. and VI., algebra to the binomial theorem), and the joint subject of geography and English history.

At the last examination 128 candidates competed for 18 vacancies, the first obtaining 1,595 marks, and the eighteenth 1,340, out of a maximum total of 2,100. Having regard to the value of the posts, these figures do not indicate any severe standard of competition.

The salary of an assistant surveyor of taxes commences at £100, and rises by annual increments of £10 to £180. About four years' service, however, usually suffices for promotion to a fourth-class surveyorship at £200 a year, advancing by £12 to £380. On entering the third class a surveyor receives £430, with £15 increments up to £550. There are also a limited number of appointments in the second and first classes—the latter carrying a maximum salary of £700 a year—so that the prospects afforded by an assistant surveyorship are distinctly attractive.

Estate Duty Clerkships. "Clerks of the First Division in the Estate Duty Department" (to give them their official title) are really experts employed to enter particulars of wills and settlements in the official registers, to examine affidavits as to the estates of deceased persons, and to perform other legal duties in connection with the assessment of Government dues on legacies and successions. They are paid an initial salary of £150, rising by £15 yearly to £300, and thence by £20 to £500; and have excellent chances of higher positions up to £800 a year. So valuable are these appointments that in recent years a number of them have been included in Class I. Clerkships [see page 2158]. Usually, however, they are offered for open competition among candidates between 21 and 27 years of age who have served articles to a solicitor and have passed the final law examination. For posts in Edinburgh the legal qualification is that of Scottish law agent or Writer to the Signet.

An outstanding feature of the Estates Duty Clerkships examination is the obligatory test

in the law of real and personal property, including conveyancing. This subject carries nearly half the total number of marks (900 in 2,100), and proves a fatal stumbling-block to a large proportion of the contestants. The other papers are in simple English subjects, constitutional history, and two of the three languages—Latin, French, and German.

Clerks for Port Service. Except that candidates are allowed to take five optional subjects in place of four, and that the fee is £3 instead of £2, examinations for second-class clerks for port service in the Customs are identical with those for Second Division clerks, described on page 2427. It is generally agreed, however, that the former are the more valuable appointments. Although the commencing salary is the same, the scale of increments is more liberal, and there are far wider possibilities of promotion. The staff of port service clerks being somewhat large, examinations are held at fairly regular intervals of about a year for a score or more of vacancies; and as the age limits are the same as for the Second Division, students who have the latter grade in view should certainly avail themselves of the chance offered by one of these Customs contests. It will be remembered that boy clerks are entitled to claim service marks when competing for such appointments.

The pay of second-class clerks for port service begins at £70, increasing by £5 yearly for four years, and afterwards by £10, to £200—the limit of the lower section. On entering the upper section they progress by £10 to £300; and when advanced to the first class receive £320, with £15 increments up to £400. They are also eligible for higher posts, including collectorships at the various ports, with salaries varying from £320 up to £800 and £1,000 a year, according to the size of the port.

Outdoor Officers. The outdoor establishment of the Customs is divided into two branches—the landing and warehousing staff, recruited by assistants of Customs; and the waterguard and preventive staff, whose members enter as preventive men. Admission to the outdoor department of the Inland Revenue is obtained through the contests for assistantships of Excise.

Assistants of Customs. From 50 to 100 appointments of this class are filled every year by means of competitions—usually held in January and July—that are open to all unmarried men between 18 and 21 years of age who satisfy the prescribed conditions as to health and physique. As is imperative in a service involving a good deal of hard work and exposure, these requirements are fairly severe.

Applicants must be at least 5 ft. 4 in. in height and of proportionate chest development. The latter standard is fixed at 32 in. for the minimum stature, and advances half an inch for every extra inch of height up to 5 ft. 10 in., for which a chest measurement of at least 35 in. is essential. The girth is calculated, by the way, as the mean or average of the measurements obtained with an expanded and a deflated chest. Any defect of vision is regarded by the authorities as a disqualification.

A clear idea of the character of the educational contests may be gained from the table given below. It shows the marks obtained by the highest and lowest successful candidates at a recent competition, which was attended by 802 students.:

EXAMINATION FOR CUSTOMS OFFICERS

Order of Merit.			[illegible]				Total.
Max. ..	400	800	800	400	400	400	3200
No. 1 .	284	800	576	337	352	352	2701
No. 60 .	300	640	504	260		311	2275

Simple as the examination is, there are no obligatory subjects; but the competition is so keen that—as our table shows—good marks in every paper are absolutely essential for success. Candidates who have served as boy clerks now receive service marks at these contests, and may deduct two years from their actual age if they have served for that term.

Salaries and Duties. Assistants of Customs are appointed on probation for a year, and are liable to serve at any port or station in the Kingdom. They receive £70 a year on appointment, rising by £5 yearly to £105. Within five or six years after entering the service, however, they may expect promotion to the grade of second-class examining officer, with a salary beginning at £110 and a yearly increment of £7 10s. to £250. In order to advance further, a departmental examination in Customs work must be passed. As vacancies arise, officers thus qualified are admitted to the first class and receive £230 a year, rising by £10 to £340. An intelligent and capable official is sure of the last-mentioned salary at least.

From the ranks of the senior examining officers special promotions are made, according to merit, to the responsible position of Customs surveyor. These officers are in three classes, with respective maxima of £420, £480, and £550. There are also a handful of better paid appointments; and as higher posts are filled by the advancement of deserving subordinates, capable officers may go far in the service.

The work of Customs officers is manifold, interesting, and sometimes exciting. It includes boarding and rummaging vessels, quarantine duty, the examination of baggage, waterguard service, dock and warehouse work in connection with dutiable imported goods, and many other duties afloat and ashore. Changes of station are frequent, and there is a good deal of night work and extra duty, for which special remuneration is paid. Despite its occasional hardships, men of active, self-reliant temperament find the life pleasant enough.

The Preventive Service. This branch of the Customs is occupied with less responsible and technical duties, and offers far fewer chances of advancement than the landing and warehousing section. Recruits were formerly enrolled as Customs boatmen, but now are termed Preventive Men. The appointments are in the gift of the Treasury, and are generally secured through the influence of a member of Parliament. Candidates must be between 17 and 20 years of age, at least 5 ft. 4 in. in stature, and 34 in. round the chest; or if the height is 5 ft. 10 in., the minimum chest measurement is 35 in. They are required to pass a qualifying examination of the simplest character in reading, writing, and elementary arithmetic.

Preventive men start at £55 a year, rising by £1 10s. annually for five years and afterwards by £2 10s. to £85. On promotion to the grade of preventive officer, this salary becomes £95 a year, with £5 increments to £150. There is an upper section in this grade rising to £200, and a few higher posts with salaries ranging up to £650; but only about one-half of the preventive officers can advance beyond £150.

Assistants of Excise. These officers are rather more liberally paid, on the whole, than their colleagues in the Customs. An assistant of Excise, after a preliminary course of instruction at a brewery and distillery, begins his service on a salary of £50 a year, but receives an "officiating allowance" of 2s. a day when actively employed, which raises his actual earnings to about £80 or £85. After receiving six yearly increments of £5 each, he becomes a second-class officer at a salary of £115, advancing by £7 10s. to £160. The officiating allowance ceases in this grade, but there is instead a "subsistence allowance" not exceeding 7s. 6d. weekly for the expenses incurred by absence from home; and in districts where it is necessary to keep a horse, £40 a year is allowed for that purpose.

Deserving officers are promoted in order of seniority to the first class, with a salary of £180 and annual increments of £7 10s. for six years and then of £10 to £250. As the number of first-class appointments is limited, and promotion is consequently often delayed, officers who, after 15 years' approved service, have not been advanced to that class receive special increments of £7 10s. yearly until so promoted.

Every meritorious member of the department is thus assured of at least £250 a year, but beyond this point promotion is tardy, and for many officers is practically out of reach. A departmental examination admits their more fortunate colleagues to the higher grades, comprising those of assistant supervisor (at £250 and allowances), supervisor (£280 to £400), inspector (£450 to £700), and collector (£500 to £800).

Life as an Excise Officer. Employed sometimes in busy town stations, sometimes in remote country districts where the work is pleasantly light, the Exciseman enjoys a great deal of variety in his duties and surroundings. His work may be summarised under the following heads—distillery survey, brewery survey, levying duty at bonded warehouses, and duties in connection with licences. For the most part it is done without supervision, combining liberty with responsibility. Town posts may involve an unwelcome amount of night duty at breweries and distilleries, but in country areas at least—the ancient hatred of the Exciseman having long ago died out—the life is distinctly an agreeable one.

The Entrance Examination. Open competitions for assistantships of Excise are held, as a rule, in May and November of each year. The age limits are 19 and 22, but candidates who have served for two years as boy clerks are admitted until 23, besides receiving service marks in the contest. "Any serious defect of vision" is a bar to the service, but no standard of height or chest measurement is prescribed as in the Customs.

Under existing regulations the examination scheme comprises only handwriting, English composition, arithmetic, general geography, and higher arithmetic (including mensuration). On January 1st, 1907, a slightly more extended scheme will come into force, retaining the first four subjects named above, and adding to these the following three papers, of which only two may be taken by any candidate: English history (from A.D. 1485), mathematics, and elementary chemistry.

Owing probably to the attractions of life in the Excise (particularly for country youths), and the simple character of its entrance competition, vacancies for assistantships are contested with an eagerness unrivalled in any other branch of the national service. For the 40 or more appointments offered at each examination, between 700 and 1,000 candidates usually strive, and in one recent instance, at least, they reached the startling ratio of 31 competitors to every place. The marks obtained by those who succeed are correspondingly high, about 80 per cent. of the maximum aggregate being usually needed to secure an appointment.

The Government Laboratory. Assistants who have served for six months in either the Excise or the Customs service may obtain permission to attend a competitive examination in science subjects held in July of each year for eight studentships in the Government laboratory in London. Successful candidates receive two years' instruction at South Kensington in theoretical and practical chemistry, and, on passing a further examination at the end of that period become temporary assistants at the laboratory. While thus engaged they receive the pay of their Excise rank, with compensation for loss of emoluments, and the most promising of their number are selected to fill vacancies in the permanent staff of analysts. These officials are paid £160 a year, rising by £15 annually to £350, and on promotion to the first class advance £20 yearly from £400 to £550. There are higher posts obtainable, and a laboratory studentship unquestionably offers to a young member of the Customs or Excise who possesses the requisite ability and aptitude for science the first step in a very successful career.

Continued

SPANISH—ITALIAN—FRENCH—GERMAN

Spanish by Amalia de Alberti; Italian by F. de Feo; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

SPANISH

Continued from page 2631

By Amalia de Alberti

NUMERALS

Cardinal. The cardinal numbers are those which answer the question How many ? as in English.

1, uno	6, seis	11, once
2, dos	7, siete	12, doce
3, tres	8, ocho	13, trece
4, cuatro	9, nueve	14, catorce
5, cinco	10, diez	15, quince

16, diez y seis	90, noventa
17, diez y siete	100, ciento
18, diez y ocho	101, ciento y uno
19, diez y nueve	200, doscientos
20, veinte	300, trescientos
21, veinte y uno, etc., or veintiun, etc.	400, cuatrocientos
	500, quinientos
30, treinta	600, seiscientos
31, treinta y uno, etc.	700, setecientos
40, cuarenta	800, ochocientos
50, cincuenta	900, novecientos
60, sesenta	1,000, mil
70, setenta	1,000,000, un millon *or* un cuento.
80, ochenta	

The cardinal numbers are invariable except *uno* and *cientos*, which take *a* before a feminine substantive. Example: *doscientos hombres*, two hundred men; *trescientas mujeres*, three hundred women.

Ciento, one hundred, is invariable.

The contraction of *uno* and *ciento* to *un* and *cien* have already been explained.

Ciento and *mil* are never preceded by *un*, but one million is always *un millon*.

Tens of hundreds cannot be used in reading Spanish figures, the year nineteen hundred and five can only be expressed as *mil novecientos y cinco*, one thousand nine hundred and five.

Ordinal. The ordinal numbers denote rank or order, as in English.

1st, primero	17th, décimo séptimo
2nd, segundo	18th, décimo octavo
3rd, tercero	19th, décimo nono
4th, cuarto	20th, vigésimo
5th, quinto	21st, vigésimo primo
6th, sexto or sesto	22nd, vigésimo segundo
7th, séptimo or sétimo	23rd, vigésimo tercio
8th, octavo	24th, vigésimo cuarto
9th, nono or noveno	25th, vigésimo quinto
10th, décimo	26th, vigésimo sexto (sesto)
11th, undécimo	
12th, duodécimo	27th, vigésimo séptimo (sétimo)
13th, décimo tércio	
14th, décimo cuarto	28th, vigésimo octavo
15th, décimo quinto	29th, vigésimo nono
16th, décimo sesto	30th, trigésimo

31st, trigésimo primo	200th, ducentésimo
40th, cuadragésimo	300th, trecentésimo
50th, quincuagésimo	400th, cuadragentésimo
60th, sexagésimo	500th, quingentésimo
70th, septuagésimo	600th, sexcentésimo
80th, octogésimo	700th, septengentésimo
90th, nonagésimo	800th, octogentésimo
100th, centésimo	900th, nonagésimo
101st, centésimo primo	1,000,000th milésimo

All the ordinal numbers agree with the noun in gender and number, following the general rule of adjectives ending in *o*.

COLLECTIVES. Collectives are numeral substantives expressing a definite quantity: *un par*, a couple; *una veintena*, a score; *una decada*, a decade; *una quincena*, a fortnight; *una docena*, a dozen; *una gruesa*, a gross.

FRACTIONS. Fractions are expressed by the ordinals up to ten and afterwards assume the ending *avo*; plural, *avos*. Examples: $\frac{1}{5}$, *un quinto*; $\frac{1}{10}$, *un décimo*; $\frac{1}{11}$, *un onzavo*; $\frac{3}{12}$, *tres dozavos*.

Half as a noun is *la mitad*, but *un medio* is used in calculation. *La mitad de un pan*, the half of a loaf; *un pan y medio*, a loaf and a half.

MULTIPLICATIVES. Multiplicatives answer the question. How many fold? *Doble, duplo*, double or twofold; *triple, triplo*, triple or threefold; *cuadruplo*, fourfold; *quintuplo*, fivefold; *décuplo*, tenfold; *céntuplo*, a hundredfold.

TIME. The time of day is expressed by the cardinal numbers with the definite article in the feminine, *horas* being implied:

¿ Que hora es ? Es la una, What time is it ? It is one o'clock. *Son las cinco*, it is five o'clock; *á las dos*, at two o'clock.

DATE. The day of the month is expressed by the cardinal number and definite article in the masculine, *dia* being implied.

El diez y seis de agosto, the 16th of August; *el cinco de enero*, the 5th of January.

Vocabulary	**Vocabulario**
COMMERCE	COMERCIO
A desk	Un bufete
A banker	Un banquero
A partner	Un socio
The bank	El banco
A broker	Un corredor
A stockbroker	Un agente de cambio
A contract	Un contrato
A cashier	Un cajero
A merchant	Un negociante
A bookkeeper	Un tenedor de libros

A clerk	Un dependiente
A receipt	Un recibo
A postage-stamp	Un sello de correos
A share	Un accion
A shareholder	Un accionista
An insurance	Un seguro
The fall	La baja
The rise	La alza
Stock-jobber	Agiotador
Stockbroker	Agiotista
A bill	Un pagaré
A bill to order	Un pagaré a la orden
An account	Una cuenta
The correspondence	La correspondencia
A letter of credit	Una carta de crédito
A loan	Un empréstito
An endorsement	Un endorso
The discount	El descuento
An invoice	Una factura
The freight	El flete
A letter	Una carta
A repayment	Un reembolso
To sign	Firmar
A company	Una compañia
A joint-stock company	Un sociedad en comandita
	La venta
	La venta por mayor
To sell	Vender
A banknote	Un billete de banco
A pound sterling	Una libra esterlina
A cheque	Un cheque
A gold piece	Una moneda de oro
A shilling	Un chelin
A centime	Un céntimo
A league	Una legua
A foot	Un pié
A cubic foot	Un pié cúbico
An inch	Una pulgada
A ton	Una tonelada
Time	**Tiempo**
An hour	Una hora
The hour has sixty minutes	La hora tiene sesenta minutos
The minute has sixty seconds	El minuto tiene sesenta segundos
The day is composed of twenty-four hours	El dia se compone de veinte y cuatro horas
The year is composed of twelve months	El año se compone de doce meses
The Arts	**Las Artes**
Drawing	El dibujo
Painting	La pintura
Engraving	La grabadura
Sculpture	La escultura
Singing	El canto
Elocution	La declamacion
Music	La musica
A draughtsman	Un dibujante
A painter	Un pintor
An engraver	Un grabador
A sculptor	Un sculptor
A singer	Un cantante
An actor	Un actor
A musician	Un musico
The pencil	El lapiz
The brushes	Las brochas
The burin	El buril
The chisel	El cinsel
A tenor	Un tenor
A baritone	Un barítono
A bass	Un bajo
A soprano	Una soprano
A contralto	Una contralto
The opera	La ópera
The Italian opera	La ópera italiana
The German opera	La ópera alemana
The French opera	La ópera francesa
A musical comedy	Una zarzuela
A tragedy	Una tragedia
A drama	Un drama
A farce	Un sainete
A comedy	Una comedia
A comedy of manners	Una comedia de costumbres

Exercise VI. (1)

Translate the following into Spanish:

1. The banker and his partner are talking
. . . . están hablando
with the broker about the contract. 2. The
con . . . . . . acerca . . . .
bookkeeper is making [up] the accounts for the
. . . . haciendo . . . .
end of [the] year. 3. This gentleman has a
fin . . . . caballero tiene . .
letter of credit upon our house. 4. I have a
. . . . sobre nuestra. . . . . Tengo . .
bill to order for £10,000 sterling. 5. To be a
. . . . Para . .
good painter, engraver, or sculptor, it is necessary
buen . . . . ó . . . . es . . preciso
to be a good draughtsman. 6. One can be a
. . Puede uno .
good musician and not know how to sing, and
. . . . saber . . . .
sing well without being a musician. 7. The
. . . . sin . . ser . . . .
Spanish musical comedies are prettier than the
. . . . bonitas . . . . .
English. 8. The Italian operas are more pleasing
. . . . amenas
than the German, and the French are the gayest.
. . . . alegres

Exercise VI. (2)

Translate the following into English:

1. Quinientos jóvenes, y cuatrocientas mujeres
. . . .
dejaron su pays nativo. 2. Un par de amigos
left . . . .
pelearon. 3. La compañia perdió un millon de
quarrelled . . . . lost . . . .
duros. 4. El banco se abrirá el primero del año.
. . . . will open . . . .
5. El empréstito se pagará el dia octavo
. . . . will be paid . . . .
del mes. 6. El dependiente ha escrito cien
. . . .
veces. 7. Dame la mitad de un pan. 8. Daré
times . . Give me . . . . I will give
seis panes y medio.
. . . .

PROSE EXTRACT VI.

From "El Diablo Cojuelo" ("The Lame Devil") by Luis Velez de Guevara.

DON CLEOFAS AND THE LAME DEVIL VISIT THE MADHOUSE.

"This is the madhouse," said the Lame Devil, "lately instituted in the capital among certain charitable works left by a very rich and very wise man, where they punish and treat forms of madness not hitherto accounted such." "Let us go in through this open wicket," said Don Cleofas, "and see this novelty in madmen." Suiting the action to the word, they passed in one after the other, and going through a porch where some of the convalescents were begging alms for those who were raving mad, they reached a square courtyard surrounded by small cells. At the door of one of them a man, very well dressed, was seated on a bench, writing on his knees, without raising his eyes from the paper. "This," said the Lame Devil, "is a mad reformer, who took to saying that the value of the farthing should be reduced, and he has written more sheets of paper on the subject than were taken up by the trial of Don Alvaro de Luna." "Good luck to whoever brought him here," said Don Cleofas. "These are the worst madmen in the kingdom."

DON CLEOFAS Y EL DIABLO COJUELO VISITAN LA CASA DE LOCOS.

"Esta es la casa de los locos, dijo el Cojuelo, que ha poco se instituyó en la corte, entre unas obras pias que dejó un hombre muy rico y muy cuerdo, donde se castigan y curan locuras que hasta ahora no lo habian parecido." "Entremos dentro," dijo don Cleofas, "por aquel postiguillo que está abierto y veamos esta novedad de locos." Y diciendo y haciendo, se entraron los dos, uno tras otro, pasando un zaguan donde estaban algunos de los convalecientes pidiendo limosna para los que estaban furiosos, llegaron á un patio cuadrado, cercado de celdas pequeñas. A la puerta de una de ellas estaba un hombre muy bien tratado de vestido escribiendo sobre la rodilla y sentado en una banqueta sin levantar los ojos del papel. El Cojuelo dijo: "Aquel es un loco arbitrista que ha dado en decir que ha de hacer la reduccion de los cuartos, y ha escrito sobre eso mas hojas de papel que tuvo el pleito de don Alvaro de Luna." "Bien haya quien le trajo á esta casa, dijo don Cleofas, que son los locos mas perjudiciales de la republica." "En

"In that other little lodging full of papers and books," continued the Lame Devil, "is a great grammarian who lost his wits trying to find the gerund of a Greek verb. The man at the door of the other cell, with a knapsack on his shoulder and white breeches, was brought here because, being a coachman and always used to riding, he engaged himself as a running footman."

esotro aposentillo lleno de papeles y libros," prosiguio el Cojuelo, "está un gramaticon que perdió el juicio buscándole á un verbo griego el gerundio. Aquel que está á la puerta de esotro aposentillo con unas alforjas al hombro y en calzon blanco, le han traído porque siendo cochero que andaba siempre á caballo tomó oficio de correo de á píe."

Continued

KEY TO EXERCISE V. (1).

1. Vámonos de viaje, empaquete la maleta y el mundo con cuidado.
2. A que hora se ha ordenado el carruaje? Para las ocho.
3. Quién va á tomar los billetes? El courrier los va á tomar.
4. Se ha reservado el compartimientó? Si señor.
5. A que hotel iremos? Al hotel Bristol.
6. He tomado billetes para la ópera.
7. He comprado dos vestidos de seda y uno de paño, fué despues á la pasteleria, á comer unos pasteles deliciosos.
8. Fuimos afortunados de obtener una audiencia privada del Papa.
9. El Rey y la Reina son muy amables.
10. Hemos gastado mucho; contamos nuestro dinero.
11. Me alegro de volver en casa; estoy cansada; hay que despedir el courrier.

KEY TO EXERCISE V. (2).

1. That man is rich, but his brother is richer; his father is very rich, and his uncle extremely rich.
2. That woman is amiable; her sister is very amiable.
3. Love is ardent; it is very ardent sometimes.
4. The stars are bright; the sun is very bright.
5. The horse is strong; the mule is very strong.
6. Death is cruel, very cruel.
7. This statue is old, very old.
8. Socrates was very wise.
9. That child is small, this one is smaller.
10. This man is wise, but his father is superior in wisdom.

Continued

ITALIAN

Continued from page 2633

By Francesco de Feo

Possessive Adjectives

il mio (masc. plur. *miei*), my, mine
il tuo (masc. plur. *tuoi*), thy, thine
il suo (masc. plur. *suoi*), his, her, hers, its
il nostro, our, ours
il vostro, your, yours
il loro, their, theirs
altrui, other people's.

The feminine and plural of *mio, tuo, suo, nostro, vostro* (except the irregular plurals *miei, tuoi, suoi*—pron. *mee-èh-ee, too-òee, soo-òee*), are formed regularly: *la mia, le mie, la sua, le sue, i vostri, le vostre*, etc. *Loro* is indeclinable. The preceding article denotes gender and number, as: *il loro giardino, i loro libri, la loro casa, le loro sorelle. Altrui* (*ahl-troò-ee*) is also indeclinable:

non parlare degli affari altrui, Do not speak of other people's business.

The possessive adjectives in Italian do not agree with the possessor, as in English, but always with the thing possessed. This rule presents no difficulties, as it requires only that the possessive adjective should agree in gender and number with the noun to which it belongs, whether expressed or understood. Examples: *Egli vende la sua casa,* he sells *his* house; *essa vende il suo giardino,* she sells *her* garden; *io ho perduto il mio danaro, e essa ha trovato il suo:* I have lost my money, and she has found hers.

The possessive adjectives are always preceded by the article. Yet the article of the possessives (*loro* excepted) is omitted before the words *padre* and *madre*, and before nouns indicating dignity, as: *mio padre, vostra madre, sua Maestà, vostra Eccellenza.*

The article of the possessives may also be omitted when they precede a noun indicating a near relation in the singular, as: *mio fratello* or *il mio fratello; nostra sorella* or *la nostra sorella.* But in all the preceding cases, if the nouns are in the plural, or precede the possessive, or are modified by another adjective (*questo, codesto, quello* excepted), the article is indispensable—*e.g., I miei zii, le mie sorelle, le vostre madri, le vostre Maestà, il mio vecchio padre, la mia buona madre.* (But: *questo mio libro, quel vostro amico,* etc.)

The article must always be used before *loro,* as: *il loro padre, la loro madre, il loro zio,* etc.

Expressions like "a friend of mine, of his, of yours," etc., are translated into Italian by *un mio amico, un suo amico, un vostro amico* (a my friend, a his friend, etc.).

NOTE. Generally, the possessives are not so much used in Italian as in other languages, the determinative article having also a possessive meaning, as: *Datemi il bastone,* give me *my* stick (and not that of someone else).

EXERCISE XIV.

primo (*preèmo*), first
cameriere (*cahmeh-ree-èhreh*), waiter
nàscita (*nàhsheetah*), birthday
nonno, grandfather
ottanta, eighty
anno, year
pàtria (*pàh-tree-ah*), native country
il migliore (*meelee-òreh*), the best
invidioso (*een-vee-deeòso*), envious
preso (*prèhso*), taken
spera, (she) hopes
di chi? (*dee kee?*), whose?
aver ragione (*rah-dgee-òneh*), to be right
aver torto, to be wrong
aver....anni, to be....years old
quanti anni ha....? How old is....?
mio figlio ha dieci anni, my son is ten years old (literally, my son has ten years).

1. Mio padre e mia madre. 2. Sua Maestà il Re. 3. Sua Altezza Reale. 4. Le loro Maestà. 5. Il loro zio è primo cameriere d' onore di sua Santità Pio X. (*dècimo,* pron. dòhcheemo). 6. Ho comprato un bel regalo per la nàscita della mia sorella. 7. Il mio nonno ha ottant'anni. 8. Questo cappello non è il mio; voi avete preso il mio e io ho preso il vostro. 9. I libri sono i nostri migliori amici. 10. Codesto vostro amico è molto gentile. 11. Il mio danaro è buono come il vostro. 12. Essi hanno ragione, ma io non ho torto. 13. Sua madre spera di èssere a Parigi stanotte. 14. Non essere invidioso della fortuna altrui. 15. Solo i nemici della tua patria siano i nemici tuoi. 16. Se avèssimo avuto tempo saremmo andati a teatro con vostra zia. 17. Col vostro aiuto speriamo (we hope) di avere indietro i nostri danari.

Indefinite Adjectives. The indefinite adjectives are:

ogni (*ònee-ee*), every, each, all
uno (*oono*), a, an (see indefinite article)
alcuno (*ahlcoòno*), some
taluno (*tahloòno*), some
ciascuno (*chee-ahscoòno*), each, every
certo (*chèhrto*), certain
nessuno (*nehssoòno*), no
niuno (*nee-oòno*), no
nullo (*noollo*), no

The following are indefinite adjectives of quantity:

poco, little
qualche (*kooàhl-keh*), some
alquanto (*ahlkooàhnto*), a little
parecchi (*pahrèhkée*), several
tanto, so much
quanto (*kooàhnto*), how much, as
altrettanto (*ahltrehttàhnto*), as much
molto, much
troppo, too much
tutto, all, the whole

1. *Ogni* (before any vowel, also *ogn'*) is indeclinable, and never takes the article. It is used only in the singular, before masculine or feminine nouns. Example: *Ogni cosa,* every thing; *ogni uomo* (or *ogn' uomo*), every man.

2. *Uno,* which is really a numeral adjective, like other adjectives, may be used as a substantive, and then it means one, a person. Example: *Quando uno è pronto,* etc., when one is ready, etc.; *quando uno non ha danaro,* when one has no money. In this sense it has also the plural: *gli uni, le une. Gli uni, le une,* and *gli altri, le altre* are often correlative, as: *Gli uni dicèvano bianco, gli altri nero,* Some (the ones) were saying white, some (the others) black.

3. *L'un con l'altro, l'una con l'altra, gli uni con gli altri, le une con le altre,* are reciprocals, and mean one another.

4. *Ciascuno, nessuno, qualche,* are only used in the singular. Example: *Ciascuna casa,* each house; *nessuna donna,* no woman; *qualche soldato,* some soldiers.

5. *Niuno* and *nullo* are no longer used as negative adjectives. The feminine *nulla* is met with in the proverb: *Nulla nova buona nova,* no news (is) good news. *Nullo* is now used with the meaning of void, useless. Example: *Contratto nullo,* a void contract; *ogni sforzo è nullo,* every effort is useless.

6. *Tutto,* as in English, may be followed by the article: *In tutto il mondo,* in all the world; *tutti gli uòmini,* all men; *tutte le cose* (or *tutte cose*), all things, everything.

7. *Certo* may be preceded by the indefinite article, as: *Un certo signor Tale,* a certain Mr.

So-and-so; *certe ragioni,* certain reasons; *certi uòmini di male affare,* certain ill-disposed men.

8. *Parecchi, e,* may be substituted by the qualifying adjectives *diverso, vàrio,* as: *Parècchie ore,* or *varie'ore,* or *diverse ore,* several hours.

9. *Tanto* and *quanto* are often correlative. Example: *Possa tu godere tanto, quanto io ho sofferto e soffro,* Mayst thou rejoice as much as I have suffered and am suffering.

EXERCISE XV.

capìtolo (*capeètolo*), chapter
romanzo (*romàhndzo*), novel
sbàglio (*sbàhleeo*), mistake
difetto (*deefèhtto*), fault
pròprio (*pròpreeo*), own
gusto (*goòsto*), taste
effetto (*ehffètto*), effect
càusa (*càh-oo-sah*), cause
rispetto (*reespèhtto*), respect
rièscono (*ree-èhscono*), they succeed
vìvere (*veèvehreh*), to live
dèbbono (*dèhbbono*), they must
amare (*ahmàhre*), to love
meritare (*mehreetàhreh*), to deserve
senza (*sèhndzah*), without
bene (*bèhneh*), well
quindi (*koo-eèndee*), therefore

1. Qualche capìtolo. 2. Qualche romanzo. 3. Troppi sbagli. 4. Quanta gente! 5. Ogni sera. 6. Ogni uomo ha i suoi difetti. 7. Un signore ha mandato diversi regali per la signorina Maria. 8. Con poco danaro certe persone rièscono a viver bene. 9. Ciascun uomo ha i suoi propri gusti. 10. Tutti gli uòmini sono fratelli e quindi dèbbono amarsi gli uni con gli altri. 11. Gli uni dicono che abbiamo ragione, gli altri che abbiamo torto. 12. Ogni effetto ha le sue cause e nessuna causa è senza effetto. 13. Il mio fratello e la mia sorella sono andati in campagna; il nostro vècchio padre è sempre in casa; qualche amico rimane con lui ogni sera. 14. Dove sono i vostri amici? 15. Alcuni in Francia, alcuni in Italia. 16. Ogni ragazzo avrà un regalo. 17. Se l'avvocato non avrà il suo danaro in un certo tempo, il contratto sarà nullo. 18. Certi uòmini crèdono (think) di meritàr tutto il nostro rispetto, solo perchè hanno molto danaro.

CONVERSAZIONE.

Dàtemi (give me) il cappello e il bastone
Dove sono?
Sono nell' altra stanza.
Avete visto (seen) mio fratello?
Era qui poco fa (a little while ago); sarà andato a teatro col signor Giòrgio.
Quanti anni hai?
Avrò dieci anni a Natale (Christmas).
Di chi è questo portafogli?
È mio; dov' era? (where was it?)
Era su la tàvola, nella càmera di nostro padre.
Avete ricevuto lèttere dai vostri amici?
Io no; le mie cugine hanno ricevuto una cartolina postale (postcard).
Le nostre amiche hanno una bella casa.
Sì; la loro casa è molto grande, è vero; ma la nostra è molto più còmoda (much more convenient).

KEY TO EXERCISE XII.

1. A white house. 2. The white snow. 3. The cold winter. 4. A black coat. 5. Black hair. 6. That girl has blue eyes and fair hair. 7. In the large street on the right there is a very fine palace with green windows. 8. Rich people always have faithful friends. 9. The lion and the tiger are fierce animals. 10. Brother Christopher had a long white beard. 11. The trees are loaded with fruit. 12. In the world there are good people and bad. 13. Green, white, and red are the colours of the Italian flag. 14. Our house is in St. Andrew's Street. 15. The daughter of the landlady has beautiful eyes but ugly hair. 16. The days are long in winter and short in summer. 17. The boys and the girls have gone to bed, because they were very tired.

KEY TO EXERCISE XIII.

1. This luggage, not that. 2. These flowers are for you. 3. Those words (of yours) are very kind. 4. We have both said the same thing. 5. Those boys have no paper. 6. These houses and these gardens are of (belong to) an Englishman. 7. The hotels in this town are not very convenient. 8. Those pictures and those statues are the work of a great artist. 9. How much did you pay for that stick? It is very nice. 10. I do not answer, because those discourses do not interest me. 11. I put the letter in the post myself, yet the lawyer has said that he has not received it. 12. These fruits are not ripe; they are not the same you sent home this morning.

Continued

FRENCH Continued from page 2618

By Louis A. Barbé, B.A.

THE VERB

GENERAL REMARKS

1. The various changes or modifications that constitute the conjugation of a verb depend on number, person, tense, and mood.

2. There are two numbers, singular and plural.

3, Each number has a first, a second, and a third person.

4. There are three principal tenses, the present, the past, and the future. Some of these admit of subdivisions, in consequence of which there are altogether eight tenses: (*a*) the present; (*b*) the imperfect, the past definite, the past indefinite, the past anterior, and the pluperfect; (*c*) the simple future, and the future anterior.

5. The tenses are (*a*) simple, or (*b*) compound. The simple tenses are those that do not require the help of an auxiliary verb. The compound tenses are those that require an auxiliary verb.

6. There are five moods: the indicative, the conditional, the imperative, the subjunctive, and the infinitive, which includes the present participle and the past participle.

7. There are two auxiliary verbs: *Avoir*, to have, and *Être*, to be.

8. *Avoir* helps to conjugate its own compound tenses, those of *être*, those of all active transitive verbs, and those of most intransitive verbs.

9. *Être* helps to conjugate the passive voice, which has really no conjugation of its own, and simply consists of the tenses of *être* with a past participle added to them.

Avoir, to have

INDICATIVE.

(a) *Simple Tenses.*

Present.

I have, etc.

j'ai	*nous avons*
tu as	*vous avez*
il, elle a	*ils, elles ont*

Imperfect.

I had, etc.

j'avais	*nous avions*
tu avais	*vous aviez*
il, elle avait	*ils, elles avaient*

Past Definite.

I had, etc.

j'eus	*nous eûmes*
tu eus	*vous eûtes*
il, elle eut	*ils, elles eurent*

Future.

I shall have, etc.

j'aurai	*nous aurons*
tu auras	*vous aurez*
il, elle aura	*ils, elles auront*

(b) *Compound Tenses.*

Past Indefinite.

I have had, etc.

j'ai eu	*nous avons eu*
tu as eu	*vous avez eu*
il, elle a eu	*ils, elles ont eu*

Pluperfect.

I had had

j'avais eu	*nous avions eu*
tu avais eu	*vous aviez eu*
il, elle avait eu	*ils, elles avaient eu*

Past Anterior.

I had had, etc.

j'eus eu	*nous eûmes eu*
tu eus eu	*vous eûtes eu*
il, elle eut eu	*ils, elles eurent eu*

Future Anterior.

I shall have had, etc.

j'aurai eu	*nous aurons eu*
tu auras eu	*vous aurez eu*
il, elle aura eu	*ils, elles auront eu*

CONDITIONAL.

Present.

I should have, etc.

j'aurais	*nous aurions*
tu aurais	*vous auriez*
il, elle aurait	*ils, elles auraient*

Past.

I should have had, etc.

j'aurais eu	*nous aurions eu*
tu aurais eu	*vous auriez eu*
il, elle aurait eu	*ils, elles auraient eu*

IMPERATIVE.

Present.

Aie, have thou
qu'il, qu'elle ait, let him, her have
ayons, let us have
ayez, have ye
qu'ils, qu'elles aient, let them have

SUBJUNCTIVE.

Present.

That I may have, etc.

que j'aie	*que nous ayons*
que tu aies	*que vous ayez*
qu'il, qu'elle ait	*qu'ils, qu'elles aient*

Past.

That I may have had, etc.

que j'aie eu	*que nous ayons eu*
que tu aies eu	*que vous ayéz eu*
qu'il, qu'elle ait eu	*qu'ils, qu'elles aient eu*

Imperfect.

That I might have, etc.

que j'eusse	*que nous eussions*
que tu eusses	*que vous eussiez*
qu'il, qu'elle eût	*qu'ils, qu'elles eussent*

Pluperfect.

That I might have had, etc.

que j'eusse eu	*que nous eussions eu*
que tu eusses eu	*que vous eussiez eu*
qu'il, qu'elle eût eu	*qu'ils, qu'elles eussent eu*

INFINITIVE.

Present.	*Past.*
Avoir, to have	*Avoir eu*, to have had

PARTICIPLES.

Present	*Past.*
ayant, having	*eu* (m.), *eue* (f.), had
	ayant eu, having had

NOTE 1. The imperative has no third person, singular or plural, of its own, but borrows it from the present of the subjunctive. The imperfect of the subjunctive: *j'eusse eu*, etc., is used as a second form of the past conditional.

NOTE 2. The verb *avoir* and a noun are used instead of "to be" and an adjective in the following expressions:

avoir besoin de, to be in need of
avoir faim, to be hungry
avoir soif, to be thirsty
avoir chaud, to be warm
avoir froid, to be cold
avoir raison, to be right
avoir tort, to be wrong
avoir honte de, to be ashamed of
avoir sommeil, to be sleepy
avoir peur de, to be afraid of

NOTE 3. When *avoir chaud* and *avoir froid* are used of parts of the body, the definite article is used, and the construction is as follows: *j'ai chaud aux mains et froid aux pieds*, my hands are warm and my feet are cold. *Avoir chaud* and *avoir froid* express the sensation of warmth and cold, and are never used of

inanimate objects: *cette eau est chaude*, that water is hot; *le thé est froid*, the tea is cold. "To have a cold" is *avoir un rhume*, or *être enrhumé*.

Ne pas avoir, not to have

INDICATIVE.

Present. — *je n'ai pas*, etc.
Past Indefinite. — *je n'ai pas eu*, etc.
Imperfect. — *je n'avais pas*, etc.
Pluperfect. — *je n'avais pas eu*, etc.
Past Definite. — *je n'eus pas*, etc.
Past Anterior. — *je n'eus pas eu*, etc.
Future. — *je n'aurai pas*, etc.
Future Anterior. — *je n'aurai pas eu*, etc.

CONDITIONAL.

Present. — *je n'aurais pas*, etc.
Past. — *je n'aurais pas eu*, etc.

IMPERATIVE.

Present.
n'aie pas.
qu'il n'ait pas, qu'elle n'ait pas.
n'ayons pas.
n'ayez pas.
qu'ils n'aient pas, qu'elles n'aient pas

SUBJUNCTIVE.

Present. — *que je n'aie pas*, etc.
Past. — *que je n'aie pas eu*, etc.
Imperfect. — *que je n'eusse pas*, etc.
Pluperfect. — *que je n'eusse pas eu*, etc

INFINITIVE.

Present. — *ne pas avoir*
Past. — *ne pas avoir eu*

PARTICIPLE.

Present. — *n'ayant pas*
Past. — *n'ayant pas eu*

When a verb used negatively is in the infinitive the two parts of the negation, *ne pas*, remain together and come before the verb.

Avoir, conjugated interrogatively.

INDICATIVE.

Present. — *ai-je?* *a-t-il, a-t-elle?*
Past Indefinite. — *ai-je eu?* *a-t-il eu? a-t-elle eu?*
Imperfect. — *avais-je*
Pluperfect. — *avais-je eu*
Past Definite. — *eus-je?*
Past Anterior. — *eus-je eu?*
Future. — *aurai-je?* *aura-t-il? aura-t-elle?*
Future Anterior. — *aurai-je eu?* *aura-t-il eu? aura-t-elle eu?*

CONDITIONAL.

Present. — *aurais-je?*
Past. — *aurait-il eu?*

Avoir, conjugated interrogatively and negatively.

INDICATIVE.

Present. — *n'ai-je pas?* *n'a-t-il pas?* *n'a-t-elle pas?*
Past Indefinite. — *n'ai-je pas eu?* *n'a-t-il pas eu?* *n'a-t-elle pas eu?*
Imperfect. — *n'avais-je pas?*
Pluperfect. — *n'avais-je pas eu?*
Past definite. — *n'eus-je pas?*
Past Anterior. — *n'eus-je pas eu?*
Future. — *n'aurai-je pas?* *n'aura-t-il pas?* *n'aura-t-elle pas?*
Future Anterior. — *n'aurai-je pas eu?* *n'aura-t-il pas eu?* *n'aura-t-elle pas eu?*

CONDITIONAL.

Present. — *n'aurais-je pas?*
Past. — *n'aurais-je pas eu?*

Y Avoir, there to be.

INDICATIVE.

Present.

il y a, there is, there are
il n'y a pas, there is (are) not
y a-t-il? is (are) there?
n'y a-t-il pas? is (are) there not?

Past Indefinite.

il y a eu, there has (have) been
il n'y a pas eu, there has (have) not been
y a-t-il eu? has (have) there been?
n'y a-t-il pas eu? has (have) there not been?

Imperfect.

il y avait, there was (were)
il n'y avait pas, there was (were) not
y avait-il? was (were) there?
n'y avait-il pas? was (were) there not?

Pluperfect.

il y avait eu, there had been
il n'y avait pas eu, there had not been
y avait-il eu? had there been?
n'y avait-il pas eu? had there not been?

Past Definite.

il y eut, there was (were)
il n'y eut pas, there was (were) not
y eut-il? was (were) there?
n'y eut-il pas? was (were) there not?

Past Anterior.

il y eut eu, there had been
il n'y eut pas eu, there had not been
y eut-il eu? had there been?
n'y eut-il pas eu? had there not been?

Future.

il y aura, there will be
il n'y aura pas, there will not be
y aura-t-il, will there be?
n'y aura-t-il pas? will there not be?

Future Anterior.

il y aura eu, there will have been
il n'y aura pas eu, there will not have been
y aura-t-il eu? will there have been?
n'y aura-t-il pas eu? will there not have been?

CONDITIONAL.

Present.

il y aurait, there would be
il n'y aurait pas, there would not be
y aurait-il? would there be?
n'y aurait-il pas? would there not be?

Past.

il y aurait eu, there would have been
il n'y aurait pas eu, there would not have been
y aurait-il eu? would there have been?
n'y aurait-il pas eu? would there not have been?

SUBJUNCTIVE.

Present.

qu'il y ait, that there may be
qu'il n'y ait pas, that there may not be

Past.

qu'il y ait eu, that there may have been
qu'il n'y ait pas eu, that there may not have been

Imperfect.

qu'il y eût, that there might be
qu'il n'y eût pas, that there might not be

Pluperfect.

qu'il y eût eu, that there might have been
qu'il n'y eût pas eu, that there might not have been

Idiomatic Uses of Avoir. 1. *Y avoir* is used with the meaning of "to be the matter": *qu'est-ce qu'il y a?* or simply *qu'y a-t-il?* what is the matter? *Avoir* without *y* is used for "what is the matter with (you, him, etc.)?" *Qu'a-t-elle?* or *qu'est-ce qu'elle a?* What is the matter with her? *Qu'avez-vous?* or *qu'est-ce que vous avez?* What is the matter with you? *Je n'ai rien*, Nothing is the matter with me.

2. Instead of "to be," and the adjective "old," *avoir* and the noun *âge* are used in French in asking or telling the age. The word *ans*, years, must always be used in the answer.

Quel âge avez-vous? How old are you?

J'ai dix-huit ans, I am eighteen.

Quel âge avait-elle? How old was she?

Elle avait seize ans, She was sixteen.

3. *Avoir* helps to form the idiomatic expressions *avoir l'air*, to look; *avoir envie*, to feel inclined; *avoir lieu*, to take place; *avoir soin de*, to take care of:

Il a l'air de mauvaise humeur, He seems to be in a bad temper.

Le loup avait envie de la manger, The wolf felt inclined to eat her up.

Nous aurons bien soin de vos livres, We shall take great care of your books.

La première représentation aura lieu demain soir, The first performance will take place to-morrow evening.

4. *Avoir*, with the adjective *beau*, forms an idiomatic expression which is placed before a verb in the infinitive to indicate the uselessness of the action expressed by that verb:

Nous aurons beau dire, on ne nous croira pas, It will be no use our saying anything (we may say what we like), we shall not be believed.

J'ai beau lui parler, c'est comme si je chantais, It is no use my speaking to him, I might as well sing (it is as if I were singing).

5. *Il y a* not only means "ago," but is also applicable to future time. It is also used with a verb in the present instead of the English perfect, or in the imperfect instead of the English pluperfect, to express an action or state, begun at a past time and still going on:

Je l'ai vu il y a quinze jours, I saw him a fortnight ago.

Il y avait trois mois que nous étions à Paris, We had been in Paris three months.

Il y aura demain huit jours que nous sommes ici, We shall have been here a week to-morrow.

Il y a une heure que je vous attends, I have been waiting for you for the last hour.

Il y avait une heure que je l'attendais, I had been waiting for him an hour.

EXERCISE XXI.

1. They were afraid of us, but they will be still (*encore*) more afraid of you.
2. Are they not ashamed of their conduct?
3. We should be right and you would be wrong.
4. We have been very (*bien*) cold.
5. Was there not anyone in the house?
6. How old is that child?
7. He will be twelve next month.
8. He is a little more than two years older than his sister.
9. Are you very (*bien*) hungry? No, thanks (*merci*), but I am very thirsty.
10. If there were no fire we should be very cold.
11. My hands have never been colder.
12. Will you not be too warm so near the fire?
13. I was sixteen a fortnight (15 days) ago.
14. What was the matter with those children? They were afraid of that big dog.
15. They would have been less afraid of the cat than of the dog.
16. When did the first performance of the comedy (*comédie*, f.) take place?
17. It took place a little more than six months ago.
18. If you require a dictionary, take (*prenez*) mine, but take great (*bien*) care of it.
19. We have been waiting for you for the last ten minutes.
20. It will be no use your talking; you will not be believed.

KEY TO EXERCISE XX.

Quels sont les principaux aliments qui servent à la nourriture de l'homme? Ce sont le pain, la viande, la volaille, le gibier, le poisson et les légumes. Quelle est la plante que l'on cultive pour en faire le pain? C'est le blé. Qui est-ce qui cultive le blé? Les paysans le cultivent. Quelles sont les principales espèces de blé? Ce sont le froment, l'orge, l'avoine et le seigle. Qui sont ceux qui fauchent le blé? Les moissonneurs. Avec quoi? Avec des faux. En quoi change-t-on le blé pour en faire du pain? En farine. Qui est-ce qui change le blé en farine? C'est le meunier. Qu'est-ce que c'est qu'un moulin? C'est la machine avec laquelle le meunier change le blé en farine. Qu'est-ce que la pâte? C'est de la farine délayée avec de l'eau. Qu'ajoute-t-on à la pâte? On y ajoute du levain. Qui est-ce qui fait le pain? C'est le boulanger qui fait le pain. Qu'est-ce-que le pain rassis? Le pain qui n'est pas frais. Quels sont les animaux dont on mange la chair? Ce sont le bœuf, le veau, le mouton. Qu'est-ce que c'est que la viande de boucherie? C'est la chair des animaux domestiques. Qu'est-ce que le gibier? On nomme gibier les animaux qui ne sont pas des animaux domestiques et dont on mange la chair. Quels sont-ils? Le cerf, le chevreuil, le sanglier, le lièvre. Qui sont ceux qui tuent ces animaux? Ce sont des chasseurs. Avec quoi les tuent-ils? Avec des fusils. Mange-t-on la chair des oiseaux? Oui, il y a des oiseaux dont on mange la chair. Lesquels? La poule, le dindon, le canard et l'oie. Y a-t-il d'autres oiseaux dont la chair est bonne à manger? Oui, il y a d'autres oiseaux dont la chair est bonne à manger; ce sont des oiseaux sauvages tels que la perdrix, la bécasse, la bécassine, le faisan et le coq de bruyère. Quelles sont les différentes espèces de poissons? Il y a les poissons de mer et les poissons d'eau

douce. Qu'est-ce que l'eau douce? L'eau des lacs, des étangs, des rivières et des ruisseaux. Quels sont les poissons de mer les mieux connus? Ce sont la morue, le hareng, l'éperlan, le maquereau, la sole, le turbot, le merlan et la raie. Et ceux d'eau douce? Le saumon, la truite, la carpe, la perche, et le brochet. Qui sont ceux qui attrapent le poisson? Ce sont des pêcheurs. Avec quoi? Avec des lignes et des filets. Qu'est-ce qu'on mange avec la viande? Des légumes. Qu'est-ce que les légumes? Ce sont des plantes qui servent aussi à la nourriture de l'homme. Quels sont les principaux légumes que l'on cultive en France? Les pommes de terre, les choux, les betteraves, les carottes, les asperges, les fèves, les haricots et les pois. Qu'est-ce qu'un potager? C'est le jardin ou terrain où l'on cultive les légumes. Et un verger, qu'est-ce que c'est que cela? C'est le terrain où il y a des arbres fruitiers. Quels sont les principaux arbres fruitiers et leurs fruits? Le poirier dont le fruit est la poire; le cerisier qui produit les cerises; le pêcher sur lequel croissent les pêches; le brugnon dont le fruit a le même nom que l'arbre; le prunier et l'abricotier qui nous donnent les prunes et les abricots et le pommier avec le fruit duquel on fait le cidre. Quelle est la plante que l'on cultive pour en faire le vin? C'est la vigne. Quel est le fruit de la vigne? C'est le raisin.

Continued

GERMAN

Continued from page 2640

By P. G. Konody and Dr. Osten

XLVI. Relative Pronouns. These are:

(*a*) der, die, das, } who, which, *or* that
(*b*) welcher, welche, welches, }
(*c*) wer, was, who, what

They refer to a person or matter already mentioned, and help to form the relative clause. Examples: ich sah einen Mann, der (or welcher) ein Gewehr trug, I saw a man who carried a rifle; auf dem Tische stand eine Flasche, welche leer war, on the table stood a bottle which was empty, etc.

1. The pronouns (*a*) take the inflections of the demonstrative pronoun der, die, das [see XXXV.]; but the genitive plural of the relative pronoun is *always* deren.

	Singular.		*Singular.*
(*a*)	1. der, die, das	(*b*)	1. welcher, welche, welches
	2. dessen, deren, dessen		2. welches, welcher, welches
	3. dem, der, dem		3. welchem, welcher, welchem
	4. den, die, das		4. welchen, welche, welches
	Plural.		*Plural.*
	1. die 2. deren		1. welche 2. welcher
	3. denen 4. die		3. welchen 4. welche

The genitive singular welches, welcher, welches, is antiquated and generally replaced by dessen, deren, dessen. Similarly the genitive plural welcher is always replaced by deren: das Kind, dessen Eltern ich kenne, the child whose parents I know; kennen Sie die Frau, deren Kind krank ist? do you know the woman whose child is ill? Wir begrüßten die Soldaten, deren Pferde staub'bedeckt waren, we greeted the soldiers whose horses were covered with dust [dust-covered]. Zu den Vorzügen, deren sich England erfreut, gehört die gute geogra'fische Lage, one of the advantages which England enjoys, is her good geographical position [literally: to the advantages, of which England enjoys, belongs her good, etc.].

(*c*) The declension of the relative pronouns wer and was follows that of the interrogative pronouns similarly pronounced [see XXXIX]. Wer is used instead of derjenige, welcher (he who), and was instead of dasjenige, welches (that which): Wer Pech angreift, besudelt sich (proverb), who messes with pitch may dirty himself. Ertragen muß man, was der Himmel sendet, one must endure what Heaven sends [decrees].

2. The choice of welcher or der depends chiefly on considerations of euphony; but the relative pronoun der, die, das must be used where the relative clause refers to a personal pronoun: Du, der mich kennt, thou who knowest me; sie, der ich es sagte, she to whom I told it, etc. Welcher, welche, welches are also used as attributive adjectives: Er sandte uns Blumen, welche zarte Aufmerksamkeit uns mit Freude erfüllte, he sent us flowers, which delicate attention filled us with joy.

XLVII. Indefinite Pronouns.

man, one, people	etwas, something
jemand, somebody	nichts, nothing
niemand, nobody	einer, one, someone
jedermann, everybody	keiner, no one
jeder, everyone	

Man is only used in the nominative and is replaced in the other cases of the singular by the corresponding cases of ein or einer (one), which is declined like the indefinite article: 2. eines, 3. einem, 4. einen. Jemand has the same declensive terminations: 2. -(e)s, 3. -em, 4. -en; jedermann and niemand take an -s in the genitive and remain unaltered in the other cases; niemand may also take -em in the dative and -en in the accusative; einer, keiner, jeder are declined like the demonstrative pronoun dieser, -e, -es [see XXXV]; etwas and nichts are not subject to declension. In poetic language the abbreviation was is sometimes used for etwas: Wir sind zu (et)was Besserem geboren, we are born for something better.

TABLE OF ALL PRONOUNS.

1. *Personal*	ich, du, er, sie, es, wir, ihr, sie.
2. *Possessive*	mein, dein, sein, ihr, unser, euer, ihr.
3. *Demonstrative*	der, die, das; dieser; jener; solcher; derjenige; derselbe.
4. *Interrogative*	wer, was; welcher; was für ein.
5. *Relative*	der, die, das; welcher; wer, was.
6. *Indefinite*	man, jemand, niemand, jedermann, etwas, nichts, einer, keiner, jeder.

XLVIII. Strong Verbs. The following strong verbs with the stem-vowel -ä-, -ü-, -au-, -e-, -i-, and -ie change these in the imperfect and past participle into -o-.

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Conjunctive	Imperative	Past Participle
bewe'gen *	to move, induce	ich beweg-e, -st, -t	ich bewog	ich bewöge	beweg(e)	bewogen
fechten	to fight	„ fechte, fichtst, ficht	„ focht	„ föchte	ficht	gefochten
flechten	to plait, twist	„ flechte, flichtst, flicht	„ flocht	„ flöchte	flicht	geflochten
heben	to lift	„ hebe, hebst, hebt	„ hob (hub)	„ höbe	heb(e)	gehoben
melken	to milk	„ melk-e, -st, -t	„ molk	„ mölke	melk(e)	gemolken
pflegen †	to indulge in, to be given to	„ pfleg-e, -st, -t	„ pflog	„ pflöge	pfleg(e)	gepflogen
quellen ‡	to well, to flow	„ quelle, quillst, quillt	„ quoll	„ quölle	quill	gequollen
scheren	to shear	„ schere, scherst, schert	„ schor	„ schöre	scher(e)	geschoren
schmelzen	to melt	„ schmelze, schmilzest, schmilzt	„ schmolz	„ schmölze	schmilz	geschmolzen
schwellen §	to swell	„ schwelle, schwillst, schwillt	„ schwoll	„ schwölle	schwill	geschwollen
weben	to weave	„ web-e, -st, -t	„ wob	„ wöbe	web(e)	gewoben
erwägen	to consider, ponder	„ erwäg-e, -st, -t	„ erwog	„ erwöge	erwäg(e)	erwogen
gähren ‖	to ferment	„ gähr-e, -st, -t	„ gohr	„ göhre	gähr(e)	gegohren
schwären	to fester	„ schwär-e, -st, -t	„ schwor	„ schwöre	schwär(e)	geschworen
wägen ¶	to weigh, balance	„ {wäg-e, also wieg-e,} -st, -t	„ wog	„ wöge	wäg(e)	gewogen
biegen	to bend	„ bieg-e, -st, -t	„ bog	„ böge	bieg(e)	gebogen
bieten	to offer, tender	„ biet-e, -est, -et	„ bot	„ böte	biet(e)	geboten
fliegen	to fly	„ flieg-e, -st, -t	„ flog	„ flöge	flieg(e)	geflogen
fliehen	to flee, escape	„ flieh-e, -st, -t	„ floh	„ flöhe	flieh(e)	geflohen
fließen	to flow	„ fließ-e, -est, -t	„ floß	„ flösse	fließ(e)	geflossen
frieren	to freeze, to be cold	„ frier-e, -st, -t	„ fror	„ fröre	frier(e)	gefroren
gebie'ten	to command	„ gebiet-e, -est, -et	„ gebot	„ geböte	gebiet(e)	geboten
genie'ßen	to enjoy	„ genieß-e, -est, -t	„ genoß	„ genösse	genieß(e)	genossen
gießen	to pour	„ gieß-e, -est, -t	„ goß	„ gösse	gieß(e)	gegossen
glimmen	to glow	„ glimm-e, -st, -t	„ glomm	„ glömme	glimm(e)	geglommen
kriechen	to creep, crawl	„ kriech-e, -st, -t	„ kroch	„ kröche	kriech(e)	gekrochen
riechen	to smell,	„ riech-e, -st, -t	„ roch	„ röche	riech(e)	gerochen
schieben	to shove, push	„ schieb-e, -st, -t	„ schob	„ schöbe	schieb(e)	geschoben
schießen	to shoot	„ schieß-e, -est, -t	„ schoß	„ schösse	schieß(e)	geschossen
schließen	to shut, lock	„ schließ-e, -est, -t	„ schloß	„ schlöße	schließ(e)	geschlossen
sieden	to boil, seethe	„ sied-e, -est, -et	„ sott	„ sötte	sied(e)	gesotten
sprießen	to sprout	„ sprieß-e, -est, -t	„ sproß	„ sprösse	sprieß(e)	gesprossen
stieben	to scatter, disperse	„ stieb-e, -st, -t	„ stob	„ stöbe	stieb(e)	gestoben
verbie'ten	to forbid, prohibit	„ verbiet-e, -est, -et	„ verbot	„ verböte	verbiet(e)	verboten
verdrie'ßen	to vex, annoy, grieve	es verdrießt	es verdroß	es verdrösse	—	verdrossen
verlie'ren	to lose	ich verlier-e, -st, -t	ich verlor	ich verlöre	verlier(e)	verloren
ziehen	to pull, draw	„ zieh-e, -st, -t	„ zog	„ zöge	zieh(e)	gezogen
betrü'gen	to cheat	„ betrüg-e, -st, -t	„ betrog	„ betröge	betrüg(e)	betrogen
küren	to choose	„ kür-e, -st, -t	„ kor	„ köre	kür(e)	gekoren
trügen	to deceive, delude	„ trüg-e, -st, -t	„ trog	„ tröge	trüg(e)	getrogen
klimmen	to climb	„ klimme-, -st, -t	„ klomm	„ klömme	klimm(e)	geklommen
saufen	to drink, tipple	„ sauf-e, -st, -t	„ soff	„ söffe	sauf(e)	gesoffen
saugen	to suck	„ saug-e, -st, -t	„ sog	„ söge	saug(e)	gesogen

* In the sense of "to induce," bewegen is *strong:* ich bewog ihn, I induced him; in the sense of setting in motion, it is weak: wir bewegten uns, we moved; das Meer war bewegt, the sea was agitated.

† In the sense of to attend to, to carry on, to manage, to indulge in, pflegen is strong; in the sense of to nurse, to tend, to cultivate, it is weak (imperfect: ich pflegte; past participle: gepflegt).

‡ Weak in the sense of exposing something to humidity: die Erbsen wurden gequellt, the peas were soaked.

§ Weak as transitive verb: der Regen hat den Bach angeschwellt, the rain has swelled the brook.

‖ Weak, when used figuratively: das Land gährte, the country was in a state of ferment.

¶ Weak in the sense of motion (swaying gently): Sie wiegte sich im Tanze, she moved gracefully in dancing.

EXAMINATION PAPER XIII.

1. What considerations determine the use of the relative pronouns welcher or wer, and when is it essential to use the latter?
2. Which pronouns are replaced by the relative pronouns wer and was?
3. By which noun is the indefinite pronoun „man" replaced in the genitive, dative, and accusative of the singular?
4. Which declension is followed by this noun in the cases stated?
5. Which indefinite pronouns are not subject to declension?

EXERCISE 1. (On the use of the relative pronoun).

to marry, hei'raten	shipwreck, Schiffbruch (*m.*)
married, verheiratet	to perish, um'kommen
ill, krank	to lead, führen
to meet, begeg'nen	goodness, Güte (*f.*)

generally, all'gemein

I know a man who is married; I spoke to (mit) the woman whose husband is ill; these are the children whom we met yesterday in the forest. Do you know the girls whose brothers are playing [play] tennis? I met the woman whose husband perished in the shipwreck; this is the boy who led me through the forest; he is a man whose goodness is generally known.

EXERCISE 2 (*a*). Change the imperfect and past tenses into the present:

Der Soldat focht tapfer; der Wind bewegte
The soldier fought bravely; the wind moved
die Zweige der Bäume; der Sonnenun'tergang bewog mich
the branches of the trees; the sunset induced me
um'zukehren; das Mädchen hat einen Kranz geflochten;
to turn; the girl has bound a wreath;
er hob das Faß; die Schäfer haben
he lifted the barrel; the shepherds have
die Schafe geschoren; die Knaben flohen;
shorn the sheep; the boys fled;
das Wasser floß rasch.
the water flowed quickly.

(*b*). Change the present tense into the imperfect and past.

Sie genießen nicht die Schönheit der Landschaft;
You do not enjoy the beauty of the landscape;
die Schlange kriecht über den Weg; das
the snake crawls across [over] the road; the
Wasser siedet; der Jäger schießt vorzüglich;
water boils; the gamekeeper is a splendid shot;
ich verliere mein Geld; ich verbiete Ihnen dies ernst-
I lose my money; I earnestly forbid you [to do]
lich; die Blumen riechen gut; ich glaube
this; the flowers smell beautifully; I believe
der Mann betrügt mich; die Pflanze saugt ihre
the man is cheating me; the plant sucks its
Nahrung aus dem Boden.
nourishment from the soil.

EXERCISE 3. Insert the missing indefinite pronouns:

Er ist . . . . Freund. Wo . . . . geboren ist,
He is everybody's friend. Where one is born
dort heimelt es (4) . . . . . an; es ist nicht . . . .
[there] one feels at home; it is not everybody's
Geschmack zu streiten; haben Sie . . . . gehört?
taste to quarrel; have you heard something?
Nein, ich habe . . . . gehört; ich glaube (3) . . . . . .,
No, I have heard nothing; I believe nobody
den ich nicht kenne.
whom I do not know.
. . . . Hand muß dabei im Spiele gewesen sein.
Somebody's hand must have been in the game.
(Somebody must have had his finger in the pie.)

KEYS TO EXERCISES IN EXAMINATION PAPER XII. (PAGE 2639)

EXERCISE 1 (*a*). *Imperfect:* Ich blieb zu Hause; du pfiffst laut; das Mädchen rieb die Diele; wir schrieben Briefe; das Kind schrie entsetzlich; die Männer schwiegen; wir stiegen auf den Berg; ich verzieh Ihnen; der Hirt trieb das Vieh auf die Weide; der Knabe wies mir den Weg ins Dorf.

Perfect: Ich bin zu Hause geblieben; du hast laut gepfiffen; das Mädchen hat die Diele gerieben; wir haben Briefe geschrieben; das Kind hat entsetzlich geschrieen; die Männer haben geschwiegen; wir sind auf den Berg gestiegen; ich habe Ihnen verziehen; der Hirt hat das Vieh auf die Weide getrieben; der Knabe hat mir den Weg ins Dorf gewiesen.

(*b*). Ich beiße in den Apfel; weshalb bleibst du nicht bei uns? Der Künstler ergreift das Instrument; wir leiden große Schmerzen; der Kutscher pfeift eine Melodie; das Mädchen reißt eine Rose vom Zweige; die Sonne scheint hell; der Bettler schleicht an der Mauer hin; was schreiben Sie mir? Der Mann und die Frau streiten heftig.

EXERCISE 2 (*a*). Wo sind meine Tintenfässer? Ich kann nicht meine Handschuhe finden. Geben Sie mir meine Taschentücher. Die Messerklingen sind gebrochen; die Pfauenfedern sind schön; die Armbänder waren aus Gold; die Fußböden waren mit Teppichen belegt; die Weingläser sind leer; die Goldschmiede haben schöne Ringe. Aus welchem Stoffe sind Ihre Halsbinden? Geben Sie mir gefälligst die Obstmesser.

(*b*) Der Singvogel zieht im Herbst nach dem Süden; der seidene Regenschirm ist nicht sehr haltbar; das Augenlid ist geschwollen; ich kaufte eine Erdbeere. Wohin führt dieser Waldpfad; Ich besitze einen Winterrock.

(*c*). Die Hauptleute kommandierten die Truppen; ich sandte die Dienstmänner nach Hause; Kaufleute müssen rechnen können; Staatsmänner sollten nicht irren; junge Ehemänner sind gewöhnlich nachgiebig.

(*d*). Zehn Pfund Kaffee, zehn Bund Stroh, zehn Faß Petroleum, zehn Buch Papier, zehn Sack Reis, zehn Flaschen Wein, zehn Ballen Wolle, zehn Tonnen Kohle, zehn Wochen, zehn Stunden, zehn Meilen, zehn Kubik-Fuß Holz, zehn Kisten Zucker.

Continued

TERRA-COTTA

Its Early Use and its Nature. Its Manufacture and Method of Employment as a Substitute for Masonry. Faience in Building Construction

By Professor R. ELSEY SMITH

TERRA-COTTA, as is implied by its name, consists of burnt or baked earth, and is a material that has been in use for building for a very long period. It was used in Assyria and Persia, both in the form of small cubes and also in large blocks moulded in relief and enriched with colour, for lining walls. The examples of this work from Susa to be seen at the Museum of the Louvre, Paris, exemplify the splendour and permanence of this material when so treated.

The Greeks made considerable use of it, especially for small buildings and for tiles and cornices, and they employed colour for enriching the surface; the Etruscans in Italy carried its manufacture to great perfection, and achieved results that would tax the skill of a modern manufacturer. Examples of their use of this material are to be seen in the British Museum. in the complete entablature of a small building, and in a series of remarkable covers to sarcophagi; on many of these figures of nearly life size are executed, the lid being in a single piece of terra-cotta.

Modern Use of Terra-cotta. This material continued to be used by the Romans for pipes and flues, and in mediæval times was extensively employed in Italy as a building material, and admirably treated; the courts of the Certosa at Pavia may be mentioned as examples of the successful use and treatment of terra-cotta by the Italians.

Italian workmen made use of terra-cotta in England quite early in the sixteenth century, and their work at Hampton Court and elsewhere is among the earliest examples of Renaissance work in this country. In modern times it has been very extensively employed both in combination with brick and as the exclusive material for facing. The Natural History Museum at South Kensington, London, is one of the earliest examples in England of an important building so treated, and the recent addition to the Savoy Hotel, facing the Strand, London, is one of the most recent and is an example of the use of a special texture on the surface.

Advantages of Terra-cotta in Building. As a substitute for masonry, terra-cotta has both advantages and disadvantages. Of the former, one of the chief is, that when well made it resists the attack of the acids contained in the atmosphere of towns much better than do most stones. It is of great strength—about 30 per cent. stronger than good Portland stone—and may be obtained in a variety of colours; the surface may be produced with a perfectly smooth texture, or one resembling that of masonry dressed with a chisel. It is light, and is employed in hollow blocks to the greatest advantage. In situations where it is not exposed to the weather, it may be made without a glazed surface; where it is to be covered with plaster or other materials, a slight amount of distortion is not a serious defect, and this material is largely used for lintols and partition-blocks in several systems of fireproof construction. For external work, as a substitute for masonry, it must have a surface glaze to resist the attacks of weather as well as those of the acids in the atmosphere; but when so used, if carefully designed and employed in large quantities, it is less costly than stone, and the forms may be enriched without the same cost as in the case of stonework, especially when there is much repetition.

Drawbacks to the Use of Terra-cotta. Some of the principal drawbacks to the use of terra-cotta are that the materials from which it is made are liable to shrinkage during drying and burning, and, unless great care be exercised in manufacture, they are liable to shrink irregularly, with the result that blocks become distorted and the salient lines are not straight but twisted. When once burnt, the finished face in exposed work must not be touched, and any such irregularity of line or form cannot therefore be corrected, for the material itself is generally porous, and if the protecting surface is interfered with, the weather rapidly attacks and destroys the terra-cotta. If the blocks are not thoroughly homogeneous, but have an external layer of finer clay formed upon blocks composed of coarser material, there may be unequal shrinkage between the materials; fine cracks then appear on the face, wet penetrates, and in severe weather freezes, and the face scales off. Both of these drawbacks may be to a very great extent overcome by care in manufacture, but a very serious disadvantage in these days of rapid construction is the delay that is unavoidable in supplying the material and, in particular, in replacing blocks that may be condemned as unsatisfactory. The process of manufacture covers a considerable time, and cannot be hurried, so that it may often take a month or more to replace a block that has been condemned. It is sometimes customary to provide duplicates of any particularly difficult blocks that are likely to show distortion, but this is a somewhat costly provision.

Nature of Terra-cotta. Being burnt from clay, it may be considered as a material analogous to brick, though it is more carefully prepared than brick earths; but in the manner of using it on a building, it is treated, so far as actual construction is concerned, more like masonry. The blocks are prepared in a different manner from masonry, for they are moulded and

burnt, not cut from a rough block; but so far as bonding and putting together are concerned, the practice of masonry is very closely followed; in dealing with actual construction in terra-cotta, therefore, we shall describe here only the variations in practice from ordinary masons' work, and for the treatment so far as it coincides with that of masonry the reader is referred to the articles on this subject which immediately follow.

Necessity for Detail Drawings. It is necessary for a terra-cotta building that the whole of the work should be detailed very accurately, including such matters as every variation in size of quoins and dressings round openings. In masonry in a similar case the moulding only would be detailed; but, as a rule, unless great uniformity be required, the height and width of each block is left to the discretion of the mason, and depends on the sizes of stones available. In terra-cotta, on the contrary, as each block is made in a mould, every dimension must be given, and must be carefully arranged so as to secure bond with the brick walling or backing with which it is usually combined.

The height of every course in such cases must, therefore, be an exact multiple of the height of a brick course, and if the bricks to be used are not of the ordinary size, but larger or smaller, the terra-cotta must, nevertheless, be designed to suit the bricks and bond with them. The width of the bed, exclusive of any projection from the face, must also be the multiple of the breadth of a brick dimension. In continuous strings, the length is more open to variation; but it is convenient that this, too, should be a multiple of a brick length, to facilitate the use of bonding blocks. In quoins and window dressings the difference in the width of face of successive blocks should be a multiple of the width of a closer to assist bond. It is also necessary to foresee and arrange for all grooves for plaster or lead work, sinkings for fixing joinery, window bars, iron balustrades, etc., as well as joggles, rebates, etc., for fixing and bonding the terra-cotta blocks together. In masonry many of such details can be cut in the stones when fixed, but in terra-cotta they must be provided for in the moulds from which the material is cast, or formed in the block when cast and before burning.

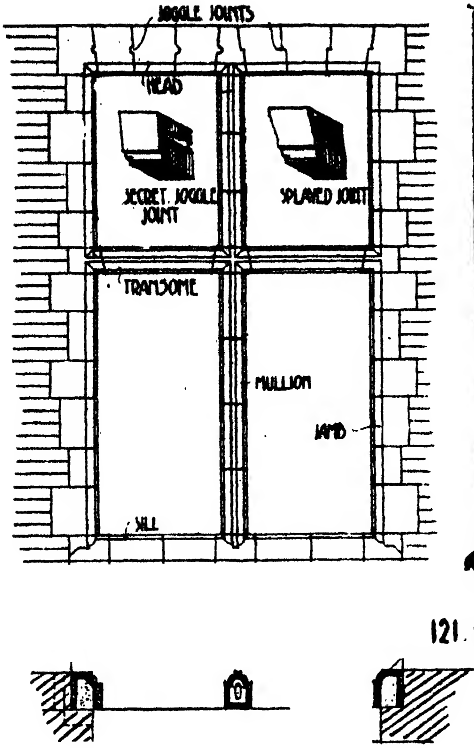
Use of Shrinkage Scales. The shrinkage of terra-cotta varies somewhat, but is considerable, and generally amounts to about $\frac{1}{12}$th of each dimension. The manufacturer must be informed if the full-size drawings represent the terra-cotta when moulded or after it has been burnt. It is often the practice to draw such details to the size of the blocks as they should be moulded, and manufacturers will supply scales, known as shrinkage scales, adequately enlarged to allow of the subsequent shrinkage to the intended size during drying and burning. It is very desirable that this method should be employed in all moulded and enriched work, for if the enlargement be left to the manufacturer, though the blocks may be correct, the character of the mouldings and enrichments may be modified in the process.

Chambering Terra-cotta. The blocks of terra-cotta are not solid as is the case with bricks or stone, but, as a rule, are hollow and have one face left open. The walls of the hollow block are kept of a uniform thickness, as far as possible, to avoid inequality in shrinkage, and are usually from 1 in. to 2 in. in thickness. If the blocks are large, cross webs are formed in the process of moulding, and these are both horizontal and vertical if necessary [**124**]; they subdivide the block into a series of chambers and serve to stiffen it, and to prevent undue distortion.

Sizes of Blocks. The individual blocks are strictly limited in size; no block can, as a rule, be formed with a cubic capacity exceeding about 3 ft., and for general purposes blocks of very much smaller size are desirable. The larger the block and the longer the surfaces and arrises the greater is the risk of distortion in the lines during the process of burning, but very much will depend on the character of the block to be used. If, for example, a block be a terminal block, as in the case of the cap to a small pier, the shape is regular, the shrinkage is likely to be regular, and for setting it is necessary merely to have a good horizontal surface for bedding on the pier; provided this is secured, a slight distortion in other portions will not be of serious moment, and may be unnoticeable. In the case of an angle block containing a group of mouldings, such as a cornice, the circumstances are different; this must have not only a true bed, but perfectly true vertical joints at each face, so that the lines of all the mouldings will carry on truly the same line in the adjoining block. It will readily be understood that any distortion is serious, and, owing to the irregular shape of the block, is more likely to occur if the block be a large one. Whenever a block is so distorted as to be unsuited for its position, there is no middle course open; the block must be used as it is produced from the kiln, or it must be rejected altogether and a new block substituted, with the consequent delay; the lines must not be corrected by chiselling, or any other work which would destroy the surface of the material.

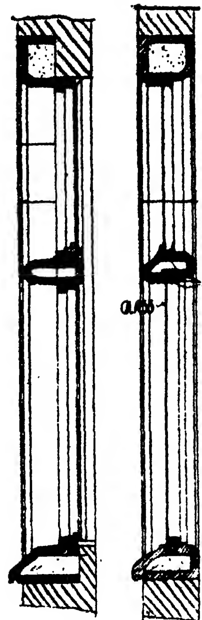
Absorption. In terra-cotta, as in stone, the question of absorption has an important relation to the durability of the material. If water be readily absorbed, it is not merely liable to expand in case of frost and split the material, but may carry into the stone, in solution, acids that will tend to disintegrate the material. When used for external work, terra-cotta that will absorb more than 10 per cent. of its own weight should not be employed, and one that absorbs a smaller proportion is to be preferred. This does not apply to the light, porous terra-cotta often used in fireproof floors which is not exposed to the action of the weather.

The Manufacture of Terra-cotta. The material from which terra-cotta is burnt is clay of a fine character—the best is refractory, containing a large proportion of silica; the presence of iron or of lime makes the terra-

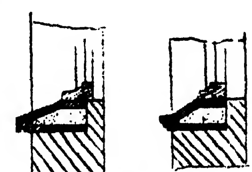


PLAN

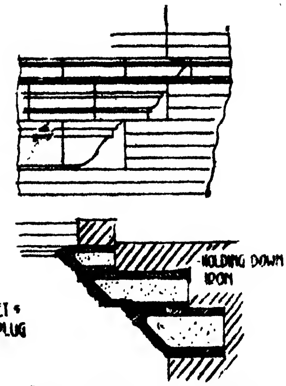
120 TERRA-COTTA TWO-LIGHT WINDOW



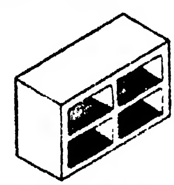
121. SECTIONS WITH AND WITHOUT FRAMES



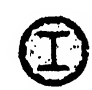
122. ALTERNATIVE FORMS OF SILLS



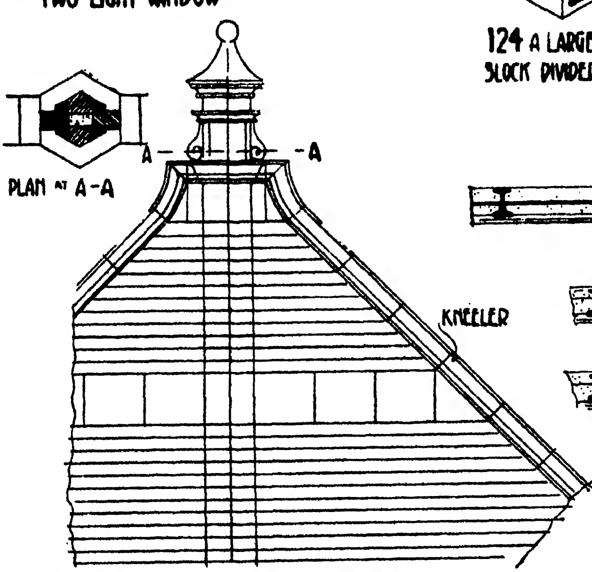
123 SECTION & ELEVATION OF A CORBEL



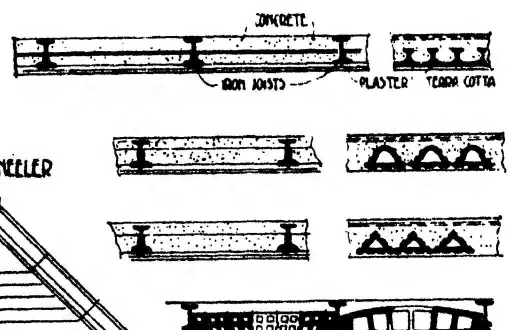
124 A LARGE TERRA-COTTA BLOCK DIVIDED WITH WEBS



125 A CASED WITH FAIENCE



126. A GABLE WITH TERRA-COTTA FINIAL ETC.

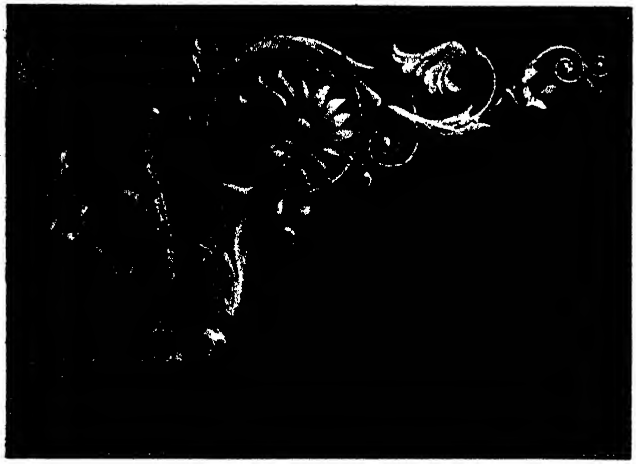


127. VARIOUS FORMS OF TERRA-COTTA USED IN FIREPROOF FLOORS

FEET

TERRA-COTTA IN BUILDING

cotta more fusible and not so hard or durable; several varieties of clay, including fireclay, may be used. These vary in the amount of shrinkage, and they are often combined in various proportions to regulate the shrinkage, and other materials, such as sand and pounded pottery, not liable to shrink, are mixed with them so as to minimise it. The materials are finely ground in a dry state, placed in water, strained, pugged, well kneaded, and finally forced into the moulds. These moulds are prepared previously; a separate mould is required for every block that differs in any respect from a block previously cast, and must include all enrichments that are intended to appear on the block. The same mould may be used repeatedly, just as in the case of a brick mould; and if terra-cotta is to be an inexpensive material, close attention must be paid to producing it with the fewest possible number of moulds, the preparation of which forms a heavy item in the expense. It is, therefore, in work in which a large amount of repetition occurs that this material is most economically employed. The moulds are smeared with soft soap before the clay, which is in a plastic state, is filled into them, and care must be taken to fill them well; on removal from the mould the clay may, if necessary, be slightly touched up, and dovetailed sinkings, if they are required, must be formed after removal from the mould.



128. SPANDRIL AND BALUSTER IN BI-COLOUR TERRA-COTTA (Doulton & Co., Ltd.)

Drying and Burning. The blocks are dried slowly with extreme care, and shielded from draughts, it being of great importance that all parts of the mould should dry uniformly. About half the shrinkage that takes place occurs during this process and before firing, and if one part of the block dries more rapidly than another, fine cracks may be set up and distortion occur.

When properly dried, the material is burnt in a pottery kiln in which the temperature is raised slowly, maintained at the requisite temperature till burning is complete, and allowed to cool slowly; the object throughout being to ensure that the further shrinkage which must occur during the process of burning shall be uniform in character. It is largely on this account that the blocks of material are moulded hollow; for were the blocks solid and of large size, there would be a tendency for the outer faces both to heat and to cool more rapidly than the centre, and cracks would be set up.

Marking and Filling the Blocks. The manufacturer marks and numbers every piece in accordance with general drawings, which show every block, and in building them in care must be taken to see that the blocks are used in the situations for which they are designed. On delivery at the building, the blocks must be carefully stored till required, and for most purposes, before fixing, the cavities or chambers in the blocks are filled up with fine concrete; they should be completely immersed in water for at least two hours before this is done, and the operation should on no account take place in frosty weather.

Lime concrete was formerly always used for this purpose, as having no tendency to expand and split the blocks while setting; but with the modern improvements in the manufacture of cement it is possible to use a thoroughly cool Portland cement without any fear of expansion sufficient to split the block. This process of filling adds strength to the block; it also adds weight; and in cases where lightness is of importance, as, for example, in a built-up cornice of considerable projection, it should be used in the lower blocks, whose principal bulk rests on the wall, to give stability, while the overhanging upper parts may be left unfilled. The open side of all such chambers is always arranged so as to come on the inner face of the block, and is entirely concealed within the wall. In floors, and in protecting steel work, the blocks are not filled, as the air space thus formed is a useful protection in itself.

Jointing Terra-cotta. When every care is taken, it is, in most cases, impossible to avoid some slight irregularity in the form of various blocks, so that were a straightedge applied to any plain surface, it would not be found absolutely true, and it is not possible, therefore, to lay terra-cotta with a fine joint, such as is used with squared masonry. The joint is usually rather thicker than an ordinary brick joint, and may be as much as $\frac{3}{8}$ in., which should suffice to allow of any permissible irregularity being adjusted; it is necessary to bear this in mind in setting out terra-cotta work.

To avoid disputes during the progress of the work, it is usual for sample blocks to be deposited with the architect, showing the extreme limit of deviation from a true straight line that will be permitted; samples should also show the extreme range of variation in tint permitted, and if more than one colour is to be employed, this may be done for every colour to be used.

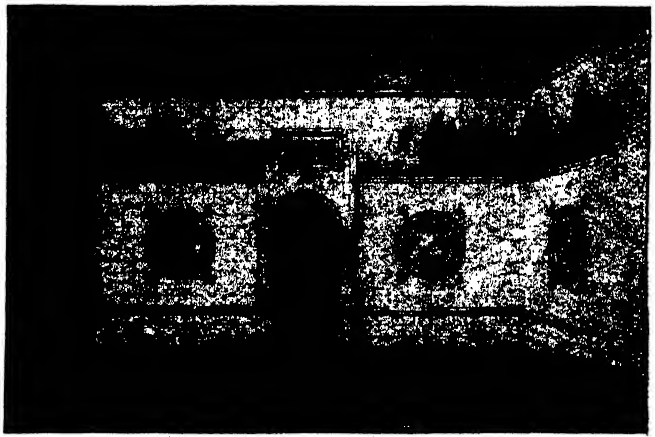
Setting the Blocks. In setting terra-cotta, the salient angle of which is moulded, or which carries a group of mouldings, as, for example, in a string or cornice, the setter must select the most prominent or important moulding by which to regulate his setting; for it will prove impossible, in some cases at least, where several mouldings occur, to set the block so that all the mouldings will run on in true lines. Every effort must be made to minimise the irregularity, and if the salient angles and important mouldings are free from obvious defects, the smaller intermediate mouldings will not attract attention, though small variations in line occur.

Colour of Terra-cotta. The colour of terra-cotta depends partly on the composition of the earth and partly on the temperature at which it is burnt. The usual colours to which terra-cotta is burnt are buff, red, white, and black, the last-mentioned being really a deep grey; two or more colours may be combined in a single elevation; or one colour may be selected for the terra-cotta and combined with brickwork of a colour that will harmonise with or form an effective contrast with it. Various other colours may be produced on terra-cotta surfaces, and while the surface is, as a rule, perfectly plain and smooth, terra-cotta is sometimes given a surface texture resembling that of masonry, or one somewhat resembling marble, as in the Savoy Hotel, London.

Its use may be confined to the more ornamental parts of a facade, such as the strings, cornices, and dressings round window and doors [120 and 126]; it is then described as moulded or enriched work; or it may be used for plain walling, so that the entire external surface of the building has a uniform facing of terra-cotta. In towns where the atmosphere is smoky, this latter treatment insures that the original appearance of the building will be less affected by the deposit of soot than where bricks with a rough surface are mingled with it. Where colour is applied to the surface of terra-cotta it is possible for decorative purposes to use more than one colour on the same block [128].

Forming Heads of Openings. The limitation in the size of blocks has been mentioned; in particular, it may be well to point out that a block, in which the length greatly exceeds either the breadth or thickness, is more liable to distortion than one in which all three dimensions are approximately the same. As a result of this limitation, it is impossible in terra-cotta construction to use long blocks as heads or sills to openings, or as mullions or transoms, in the manner usual in masonry. Such members, when employed, must be built up of a series of small blocks. In arches the terra-cotta is formed into blocks of voussoir shape, as in the case of masonry or gauged brickwork, but the blocks are much broader in face than is the case with brick voussoirs. In the case of a head the form known as a *flat arch*, already described in brickwork, is employed; in such cases, in addition to using the voussoir form for the blocks, the joint is further strengthened by the use of *joggles*, which serve to interlock the various blocks, and greatly strengthen the arch [120].

The Use of Joggled Joints. These joggles may run throughout the thickness of the block from the face to the back, in which case they will appear on the surface, or they may be concealed. In the latter case, they are stopped about 2 in. from the face, which has the appearance of a plain voussoir, the interlocking being arranged on the inner part of the block. Various forms of joggles are employed. A common form consists of a small semi-circular protuberance on one side of a block, which fits into a corresponding recess in the next block. Another method consists in breaking the lines enclosing the sides of the voussoir at about the centre of the length of the block, so that a narrow seating or rebate is formed. Both these forms, if executed in masonry, involve much labour and waste, and are rarely employed for lintols; but in forming the moulds in terra-cotta, little extra trouble or expense is involved, and the strength is considerably increased.



129. THE INTERIOR OF A GLASGOW FISH SHOP
A beautiful example of appropriate ceramic treatment. (Doulton & Co., Ltd.)

Forming Transoms and Mullions. In forming a *transom*, which is a horizontal bar dividing an opening into two heights, a springer is built into the jamb, and if there be a *mullion*, which is a vertical bar dividing the opening into two widths, into the mullion also [120]; if the width of the opening be moderate the intermediate length of transom may be formed in a single piece with a rebated and splayed joint as in a flat arch; with a wide opening it may be necessary to treat the transom as a flat arch formed of voussoirs. Mullions are built up of several blocks of terra-cotta placed vertically one above another. In the case of both mullions and

transoms it sometimes happens that the face is exposed to view all round, and in such cases the block cannot be formed with an opening at the back; it is then usual to leave both ends partially open in forming the blocks.

Forming Sills. Sills, like heads, must be formed in short lengths; in jointing them care should be taken to keep the first joint some little distance within the inner face of the jamb, or water running down the jamb will easily penetrate the joint. A terra-cotta sill may be grooved for a water-bar, as is usual with a stone sill [**121**], or a projecting tongue may be found on its upper surface which will fit into a groove in the wood sill and prevent any water passing under the latter [**122**]. Where the sill receives the jambs or a mullion, a small part of the jamb or mullion is formed in the same block as the sill, and forms a *stooling*.

Bonding the Jambs. In bonding the jambs of such an opening, in addition to increased width on the outer face, the blocks may be increased in thickness from back to front, so that a part of such blocks is built into the internal jamb whether it be square or splayed, the object of such projection being to improve the bonding of the jamb.

Stopped Mouldings and Corbels. Wherever a horizontal moulding does not run out, but is stopped and finished against another surface, it should be not merely butted against it, or in the case of a splayed surface, cut up against it; the moulding should be properly stopped against a terra-cotta face formed in the same block with it, and built into the abutting wall so as to give it a proper seating, and prevent wet entering at the joint [**123**]. Corbels should be formed in the same way; the projecting corbel, which may be moulded and enriched, should have a square seating in one piece with it for building into the wall. Large moulded corbels are sometimes built up of two or more courses of terra-cotta, to carry a bay window on an upper floor. These may start from the face of a straight wall and in the upper courses be worked into the form of an octagon or other polygonal figure, or of part of a circle.

Faience. *Faience* is a material somewhat akin to terra-cotta, and has been a good deal used in recent years for external as well as internal surfaces of walls. It is used in blocks similar to terra-cotta blocks, but these are formed of stoneware, and it can be made in rather larger sizes than terra-cotta. Stoneware is burnt from the plastic clays belonging to the Lias formation, which are found largely in the South of England, in Dorsetshire, and Devonshire; these clays contain about 76 parts of silica and 24 of alumina, with very small parts of other ingredients. In manufacture the clay is mixed with some unshrinkable materials, such as powdered burnt stoneware, ground flints, or sand, to prevent excessive shrinkage. The mixture is moulded like terra-cotta and carefully burnt in kilns at a high temperature, and becomes thoroughly vitrified throughout. The surface may be moulded or enriched much like terra-cotta; the material itself is not suitable in appearance for facing, but is covered with a glaze which may be arranged of almost any colour or tint, and permits of great variety in surface enrichment, producing, if skilfully treated, a varied, clean, and reliable surface, not liable to change its colour or to collect soot or dirt. The glaze employed may be an opaque glaze, as in the case of enamelled bricks, or a semi-transparent tinted glaze, which, with a slightly modelled surface, covers different parts of the block with varying thicknesses of the glass, producing delicate gradations in the tints. It is sometimes necessary with transparent glazes to cover the natural surface of the stoneware with a finer material composed of fine clay and applied as a *slip* to the terra-cotta before it is burnt, and this in turn receives the glaze and shows through it. So far as its use and application are concerned it is arranged for and treated in a manner similar to terra-cotta. A good example of its external use is seen in the coloured plate facing page 2785.

Terra-cotta and Faience in Internal Work. These materials are not only used for external work as a substitute for masonry, but they are much employed in the interiors of buildings, and are of special value where it is desired to protect ironwork from the direct action of fire. Light terra-cotta blocks formed by burning a mixture of clay and sawdust, of which the latter burns out leaving a porous material, are much employed as a kind of permanent centre between the small joists in several kinds of fireproof floors [**127**]. These are usually about 2 ft. long, varying in section, and concrete is filled in above them; but the blocks are as a rule hollow, and are not filled with concrete. In other cases more solid floors are constructed, as flat arches and the springer blocks are made of such a form as to encase the flange of the girder which supports the arch, and for the sake of lightness such blocks are not filled with concrete. Terra-cotta blocks are employed also to form partitions in place of brick, and are also used hollow; in all such work the terra-cotta is usually concealed from view by a coating of plaster, and the surface of terra-cotta, when it is intended to be so covered, is frequently provided with a series of dovetailed grooves to give a key to the plaster which does not adhere perfectly to the smooth terra-cotta face. Where it is desired to display this covering or casing in the finished work and to treat it decoratively, faience may be applied and may be built up so as to enclose columns or stancheons [**125**]; but for such work the material is sometimes used, not in blocks of considerable thickness as for external building, but in slabs of about 2 in. or less in thickness; the outer surface moulded, modelled, and enriched with coloured glaze, the inner surface often keyed, when it may be used as a facing to concrete filled in round the ironwork. Internal walls and partitions may also be lined with Faience for purely decorative effect and renders the use of appropriate designs possible [**129**].

Continued

LIVING PROSE WRITERS

Being the Concluding Part of Our Short Study in the English Prose of To-day, together with a Course of Reading in Contemporary Prose

Continued from page 2667

By J. A. HAMMERTON

John Morley and Frederic Harrison. Among the more important writers whose works are, perhaps, remarkable more for their social outlook than their intrinsic value as literature — though this is high — must be named JOHN MORLEY (b. 1838), who, whilst undoubtedly his "Life of Gladstone" is his magnum opus, had, before that work appeared in 1903, won a European reputation by his studies of Burke, Voltaire, Rousseau, Diderot, Cobden, Cromwell, and Machiavelli. The output is not small for one who is commonly said to have given to party politics what was meant for literature; and we have not named all his literary work, which has included much of a journalistic nature. Mr. Morley's style is marked by all the severity that characterised John Stuart Mill, whose pupil he is. He studied law with FREDERIC HARRISON (b. 1831), who may be said to have given to Positivism what was meant for literary history, but who has been a stalwart in the battle for the extension of university education. His "Choice of Books and other Literary Pieces," and "Early Victorian Literature," claim special note in these pages.

Critics of Life and Letters. In the same galley may be classed the delightful essays of AUGUSTINE BIRRELL (b. 1850), the writings, biographical and social, of GEORGE WILLIAM ERSKINE RUSSELL (b. 1853), the literary and philosophical reviews of WILLIAM L. COURTNEY (b. 1850), a worthy successor to G. H. Lewes as editor of the "Fortnightly Review," and the reviews of WILLIAM FRANCIS BARRY (b. 1849), the biographer of Newman and a weighty critic, some of whose studies in modern literature and dogma were published in 1904 under the title of "Heralds of Revolt." The prose essays of ALFRED AUSTIN (b. 1835) are of infinitely greater charm than his verse. The "Asiatic Studies" and "Tennyson" of Sir ALFRED LYALL (b. 1835) are marked by distinction of thought and feeling; the career of Lord AVEBURY (b. 1834) proves that a strenuous business life is no bar to the pursuit of literature and science; Lord GOSCHEN (b. 1831), best known as a statesman, is also a great educationalist, whose "Life" of his grandfather, the Leipzig publisher, is a notable book. Other critics of life and literature who may be grouped together here are: Sir M. E. GRANT DUFF (b. 1829), the diarist; Sir JAMES CRICHTON BROWNE (b. 1840), who has supplied the necessary footnotes to Froude's "Life of Carlyle"; Sir THEODORE MARTIN (b. 1816), whose "Life of the Prince Consort" and "Memoir of Helena Faucit, Lady Martin," are full of human interest; VIOLET PAGET ("Vernon Lee") (b. 1856), whose "Renaissance Essays" are full of charm; ALICE MEYNELL, whose essays, "The Rhythm of Life," were at once hailed as "classical"; M. E. BETHAM-EDWARDS (b. 1836), who has done so much to explain French life and thought to English readers; W. ROBERTSON NICOLL (b. 1851), whose work as editor, essayist, critic, and theologian is informed with an individual style, genuine love of books, and knowledge of life, and whose scholarship is noteworthy even in these days of versatility; H. G. WELLS (b. 1866), a novelist by compulsion, whose "Mankind in the Making" and "A Modern Utopia" prove him to be a psychologist by nature; WILLIAM ROMAINE PATERSON ("Benjamin Swift") (b. 1871), of whom the same may be said by virtue of his remarkable essay "The Eternal Conflict"; WILLIAM HURRELL MALLOCK (b. 1849), of whom also much the same remark might be made, but whose work goes deeper than that of Mr. Wells; RICHARD LE GALLIENNE (b. 1866), a true bookman, and a critic who unites sound judgment with grace of style; GILBERT KEITH CHESTERTON (b. 1873). beneath whose love of paradox is discernible the light of a far-seeing intellect; A. T. QUILLER-COUCH (b. 1863), distinguished in literary criticism as well as in fiction, his "Adventures in Criticism" being a valuable work; WILLIAM HALE WHITE ("Mark Rutherford") (b. 1857); CLEMENT KING SHORTER (b. 1858), author of "Charlotte Brontë and her Circle" and "Sixty Years of Victorian Literature"; HENRY HAVELOCK ELLIS (b. 1859); EDWARD CARPENTER (b. 1844); ROBERT BLATCHFORD ("Nunquam") (b. 1851); SIDNEY WEBB (b. 1859); BERNARD BOSANQUET (b. 1848); MILLICENT GARRETT FAWCETT (b. 1847); and GEORGE LAURENCE GOMME (b. 1853).

Historical Writers of the Present Day. In the region of history the "Napoleonic Studies" of Lord ROSEBERY (b. 1847) demand special mention, as do those also of J. HOLLAND ROSE (b. 1855). MARTIN HUME (b. 1847) has explored the Spanish and English archives, and added greatly to our knowledge of the Elizabethan period. ALBERT FREDERICK POLLARD (b. 1869) is the author of valuable Lives of Cranmer and Henry VIII. GEORGE MACAULAY TREVELYAN has written weighty studies of the England of Wycliffe and of the Stuarts. JOHN EDWARD COURTENAY BODLEY (b. 1853) is one of the greatest English authorities on modern France. JUSTIN MCCARTHY (b. 1830)—an Irishman—has written a "History of Our Own Times,"

which has commended itself to all parties. EDWARD DICEY (b. 1832) is an authority on the Balkans and Egypt. ALBERT VENN DICEY (b. 1835) has written valuable works on constitutional law. EDWARD SPENCER BEESLY (b. 1831) is the author of a vivid study of Queen Elizabeth as a "Statesman." To JAMES GAIRDNER (b. 1828) we are indebted for a standard edition of the Paston Letters and for his invaluable labours as editor of the Calendar of State Papers of Henry VIII's reign. GOLDWIN SMITH (b. 1823) is a philosopher and literary critic as well as a historian. THOMAS RICE EDWARD HOLMES (b. 1855) is the author of a "History of the Indian Mutiny" which has superseded much previous study of the subject. WILLIAM HENRY FITCHETT has done a great deal to popularise the story of the Empire. STANLEY LANE-POOLE (b. 1854), the historian and archæologist, has written voluminously and authoritatively on India and the East generally, and his biographies of Stratford de Redcliffe, Sir Harry Parkes, and many other notable men are works of standard quality. AUGUSTUS JESSOP (b. 1824) has written admirably of Elizabethan men and movements and of the mediæval Church in England. FRANCIS AIDAN GASQUET (b. 1846) is the most prominent Roman Catholic historian of our day, and a great controversialist. Sir ROBERT K. DOUGLAS (b. 1838) is a distinguished Orientalist. The work of ALICE SOPHIA AMELIA GREEN merits honourable mention by the side of that of her late husband, of "Short History" fame. JOHN HORACE ROUND (b. 1854) and ROBERT FLINT (b. 1838) have also made considerable contributions to the sum total of our historical knowledge.

A Group of Scholars. Of living writers on classical, philosophical, and economic subjects must be named SAMUEL HENRY BUTCHER (b. 1850); ALFRED J. BUTLER (b. 1850); JOHN PENTLAND MAHAFFY (b. 1839); LEWIS CAMPBELL (b. 1830); EDWARD CAIRD (b. 1835), Jowett's successor at Balliol; CHARLES WILLIAM STUBBS (b. 1845); ARTHUR JAMES BALFOUR (b. 1848), whose "Defence of Philosophic Doubt" and "Foundations of Belief" have awakened much discussion; ALFRED RUSSEL WALLACE (b. 1823); JAMES SULLY (b. 1842); EDWARD BURNETT TAYLOR (b. 1832); Sir ARCHIBALD GEIKIE (b. 1835); Sir NORMAN LOCKYER (b. 1836); RICHARD BURDON HALDANE (b. 1856); FREDERICK WOLLASTON HUTTON (b. 1836); JOHN ATKINSON HOBSON (b. 1858); JAMES BONAR (b. 1852); JOHN BEATTIE CROZIER (b. 1849); and Sir OLIVER LODGE (b. 1851).

Some Theologians and Higher Critics. Leading writers on theology and Biblical criticism include the following: SAMUEL ROLLES DRIVER (b. 1846), THOMAS KELLY CHEYNE (b. 1841), HERBERT HENSLEY HENSON (b. 1863), CHARLES GORE (b. 1853), WILLIAM BOYD CARPENTER (b. 1841), WILLIAM HENRY FREMANTLE (b. 1831), GEORGE ADAM SMITH (b. 1856), STEWART SALMOND (b. 1838), WILLIAM HENRY BENNETT (b. 1855), JAMES HASTINGS, MARCUS DODS (b. 1834), PETER TAYLOR FORSYTH (b. 1848), ANDREW MARTIN FAIRBAIRN (b. 1838), ROBERT FORMAN HORTON (b. 1855), W. F. ADENEY, CUNNINGHAM GEIKIE (b. 1824), and JOSEPH AGAR BEET (b. 1840). The names of ARCHIBALD H. SAYCE (b. 1846), the Assyriologist, WILLIAM MATTHEW FLINDERS PETRIE (b. 1853), the Egyptologist, and ERNEST A. WALLIS BUDGE, perhaps the greatest of living Assyrian and Hebrew scholars and antiquaries, also claim mention here.

Some Famous Editors. When the sum of our knowledge of the Elizabethan dramatists comes to be computed, it will be difficult to overestimate what we owe to the self-sacrificing labours of a student whose name will be searched for in vain in the ordinary books of biographical reference—A. H. BULLEN. Other leading editors are: FREDERICK JAMES FURNIVALL (b. 1825); ISRAEL GOLLANCZ (b. 1864); Sir HENRY CRAIK (b. 1846); WILLIAM ALDIS WRIGHT; WILLIAM WALTER SKEAT (b. 1835), the Chaucerian scholar; ADOLPHUS WILLIAM WARD (b. 1837), the historian of English dramatic literature; HENRY BENJAMIN WHEATLEY (b. 1838), editor of "Pepys' Diary" and student of the history and celebrities of London; JOHN WESLEY HALES (b. 1836); CHARLES H. HERFORD (b. 1853), whose "Literary Relations of England and Germany in the XVIth Century" opened up new ground for literary research and at the same time covered the area with remarkable thoroughness; R. WARWICK BOND (b. 1857), the editor of Lyly; PAGET TOYNBEE (b. 1855), the great authority on Dante; ERNEST HARTLEY COLERIDGE (b. 1846), the latest editor of Byron's poetry; ROWLAND E. PROTHERO (b. 1852), the editor of Byron's Letters; GEORGE WALTER PROTHERO (b. 1848), author of "The Life and Times of Simon de Montfort" and other historical works; WILLIAM MICHAEL ROSSETTI (b. 1829), editor of many poets, who has given us a standard edition of the works of his sister Christina; WILLIAM CAREW HAZLITT (b. 1834); WILLIAM PATON KER (b. 1855), whose "Essays on Mediæval Literature" afford a necessary corrective to dithyrambic Elizabethanism; JOHN H. INGRAM (b. 1849), author of an excellent "Life of Edgar Allan Poe," and editor of various editions of Poe's prose and poetry; EDWARD VERRALL LUCAS (b. 1868), the latest and most complete biographer of Charles Lamb, and the compiler of a charming anthology entitled "The Open Road"; WILLIAM ARCHER (b. 1856), the translator of Ibsen and a trenchant critic both of literature and the drama; ARTHUR BINGHAM WALKLEY (b. 1855), perhaps the most original of living writers on contemporary drama; GEORGE ATHERTON AITKEN (b. 1860), the biographer of Steele and the editor of the best edition of "The Spectator"; PERCY SIMPSON, whose "Scenes from Old Play Books" should be in the hands of every young student of the

English drama; EDMUND KERCHEVER CHAMBERS (b. 1866), author of a valuable work on "The Mediæval Stage"; THOMAS WRIGHT (b. 1859), the authority on Cowper; STEPHEN GWYNN (b. 1864), a leader of "the Celtic Renaissance"; ARTHUR SYMONS (b. 1865), one of the most versatile of writers; G. S. STREET (b. 1867), a graceful essayist; CHARLES WHIBLEY, author of "A Book of Scoundrels"; EDWARD ARBER, whose reprints are almost as famous as they are valuable; SIDNEY COLVIN (b. 1845), whose "Life of Landor," "Letters of Keats," and "Letters of Stevenson" are notable; HILAIRE BELLOC (b. 1870), a Roman Catholic writer, whose "Path to Rome" and "The Old Road" are of special value; THOMAS SECCOMBE (b. 1866), author of several excellent histories of literary periods and a competent editor; ARTHUR WAUGH (b. 1866), editor of Dickens, Milton, Tennyson, and Johnson, and critic of general literature; GEORGE WYNDHAM (b. 1863), whose edition of Shakespeare's "Sonnets" is distinguished by an introduction that merits more attention than it has yet received; Sir FRANK T. MARZIALLS (b. 1840); and last, but not least, SIDNEY LEE (b. 1859), whose "Life of Shakespeare" may be said to sum up all that is known of the career of the national poet, and whose "Life of Queen Victoria" is another luminous and frank summary of carefully-digested data.

A Course of Study in Contemporary Prose. To begin with HISTORY, there are two works which the student will do well to have on his bookshelves. One is Haydn's "Dictionary of Dates" (Ward, Lock), and the other "A Handbook of European History, 476-1871, Chronologically Arranged," by Arthur Hassall, M.A. (Macmillan, 1897).

A good grounding in modern European history will be gained by a study of Sir Theodore Martin's "Life of the Prince Consort," Mr. Sidney Lee's "Life of Queen Victoria" (Smith, Elder), Mr. Justin McCarthy's "History of the Four Georges and of William IV." and "History of Our Own Times, from the Accession of Queen Victoria to 1897" (Chatto & Windus), and Mr. John Morley's "Life of Gladstone" (Macmillan). All of these works are as delightful to read as they are informative. For the study of Greater Britain we commend "A Short History of the Expansion of the British Empire, 1500-1870," by William Harrison Woodward (Cambridge University Press); "Problems of Greater Britain," by Sir Charles Dilke (Macmillan); and Sir A. C. Lyall's "Asiatic Studies," "Rise of the British Dominion in India" (Murray), and the "Rulers of India Series" (Oxford University Press). We would commend also Mr. J. E. C. Bodley's "France" (Macmillan) and the "Journals" of the Royal Colonial Institute and Society of Arts.

Literary, Biography, History, and Criticism. There is, we firmly believe, no more interesting and valuable biography for the literary student than the memoir of Tennyson, by his son. Next to this we should place "The Letters of Robert Browning and Elizabeth Barrett," edited by R. B. Browning (Smith, Elder). A valuable handbook is Mr. Frederick Ryland's "Chronological Outlines of English Literature," from the year 600 to 1899 (Macmillan, 1890). Of Dr. Georg Brandes' "Main Currents of the Literature of the Nineteenth Century" and M. Frédéric Lolliée's "History of Comparative Literature" competent translations have been published by Messrs. Heinemann and Hodder & Stoughton, respectively. The first of these two works is in several volumes, and is of the first importance. Professor Saintsbury's "Loci Critici" contains a series of passages illustrative of critical theory and practice from the time of Aristotle to the day of Matthew Arnold. It is published by Messrs. Ginn. Other works of value are "Principles of Criticism" (Allen) and "Judgment in Literature" (Dent), by Basil W. Worsfold; "Studies in Literature" (Kegan, Paul), by Professor Dowden; the "Miscellanies" (Macmillan) of Mr. John Morley; "Questions at Issue" (Murray), by Mr. Edmund Gosse; the "Obiter Dicta," and its companion volumes (Elliot Stock), by Mr. Augustine Birrell; and the "Studies in Two Literatures" (Heinemann), by Mr. Arthur Symons. One cannot praise too highly the combined humour and intrinsic value to students of grammar and composition of a volume entitled "The King's English," published by the Oxford University Press (1906).

Contemporary Essayists. This ground has been well covered in our short study of Life and Letters, in which all the leading essayists are named; but we would suggest to the student the necessity of keeping abreast with current examples of the essay as they are to be found in the leading monthlies and quarterlies. One American monthly, the "Atlantic," must not be overlooked, and "Harper's Magazine" contains some of the best critical essay writing.

Greek and Latin. Professor S. H. Butcher's "Aspects of the Greek Genius," Professor Gilbert Murray's "Ancient Greek Literature," and Professor J. W. Mackail's "Latin Literature," are works that are among the best of their kind.

Continental Literature. Professor Dowden's "History of French Literature" and the other volumes in Heinemann's "Short Histories of the Literatures of the World" are commended.

Philosophy and Religion. Consult the works the titles of which are attached in any good biographical handbook to the names of the writers referred to in the fourth and fifth paragraphs of our list of the leading representative writers of the day.

Continued

Group 8
DRAWING
20
Continued from page 2683

TECHNICAL DRAWING

Scales, Instruments, Plans, and Elevations. Examples of Engineers' Drawings. Drawing as a Written Language. Colours and Lines

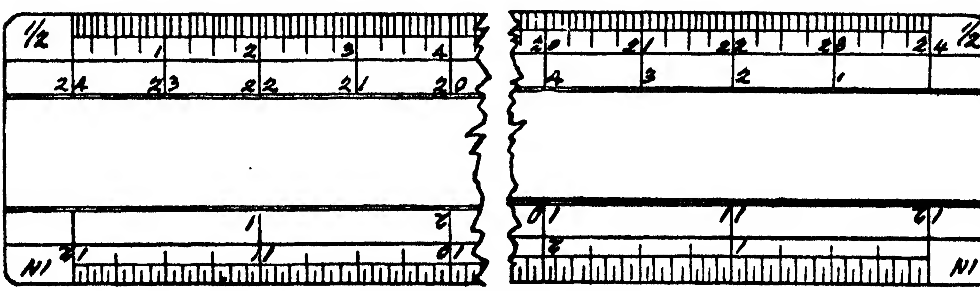
By JOSEPH W. HORNER

THE preliminary knowledge necessary for the art of technical drawing comprises geometry, projection, development of surfaces, etc., all of which sciences are dealt with under their respective headings; this knowledge, together with the accurate use of scales and instruments, forms the purely mechanical side of the craft.

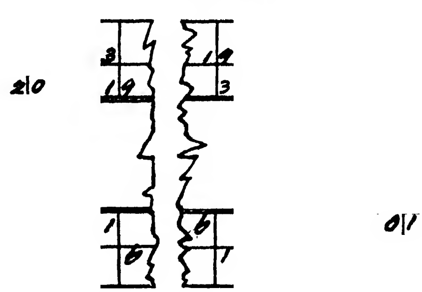
The Scales. The first essential quality for the construction of a drawing is the careful working to scale with every line and curve, and it is only by strict attention to this that success is to be attained. It must be borne in mind that a drawing should be a faithful representation of the machine or piece of work that it is intended for, and that, as such, it must not convey distorted or inaccurate proportions either as a whole or in any detail. The scales most commonly in use are as follows:

$\frac{1}{8}$ in.	to 1 ft.	or	$\frac{1}{96}$th	of	full size
$\frac{1}{4}$	,,	,,	$\frac{1}{48}$th	,,	,,
$\frac{3}{8}$	,,	,,	$\frac{1}{32}$nd	,,	,,
$\frac{1}{2}$	,,	,,	$\frac{1}{24}$th	,,	,,
$\frac{3}{4}$	,,	,,	$\frac{1}{16}$th	,,	,,
1	,,	,,	$\frac{1}{12}$th	,,	,,
$1\frac{1}{2}$	,,	,,	$\frac{1}{8}$th	,,	,,
3	,,	,,	$\frac{1}{4}$th	,,	,,
6	,,	,,	$\frac{1}{2}$	,,	,,
12	,,	,,	full size.		

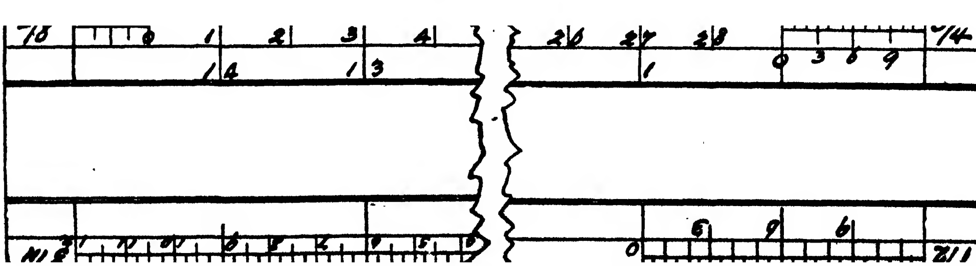
The usual scale, as an instrument, is 12 in. long, and is made of either boxwood or ivory;



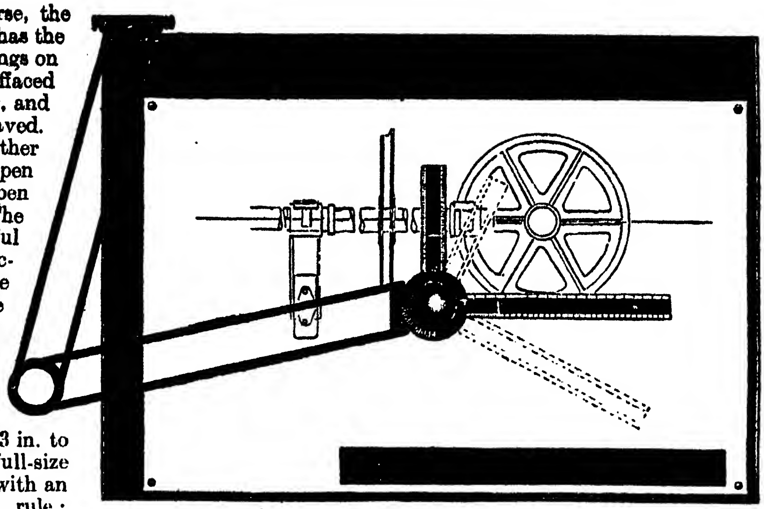
1. FULLY DIVIDED SCALE



2. OPEN DIVIDED SCALE



3. OPEN DIVIDED DOUBLE SCALE



4. UNIVERSAL DRAFTING MACHINE

the latter is, of course, the most expensive, and has the longer life; the markings on it, however, become effaced with continual wear, and require to be re-engraved. Scales are made either fully divided [1], open divided [2], or open divided double [3]. The last is a very useful form of scale, as practically the whole range of ordinary scales are embodied in the one instrument; one side being marked with $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, and 1 in. to 1 ft., the other side bearing $\frac{3}{8}$, $\frac{3}{4}$, $1\frac{1}{2}$, and 3 in. to 1 ft. Half-size and full-size drawings are made with an ordinary engineer's rule; alternatively, half-size drawings may be made with the $\frac{1}{2}$ in. to 1 ft. scale, counting each $\frac{1}{2}$ in. as 1 in.

Instruments. With regard to instruments, a useful outfit consists of one pair of 6-in. compasses, knee-jointed, and provided with pencil point, ink point, plain point, and lengthening piece; one pair of ink bows; one pair of pencil bows; three spring bows, ink, pencil and point; one or two drawing pens; protractor; and two set squares. This list may be amplified to a considerable extent to suit the taste and pocket of the draftsman, but all the essentials are contained therein. Amongst the many sizes of drawing papers manufactured, engineers practically use but two—*viz.*, imperial, 30 in. long by 22 in. wide, and double elephant, 40 in. long by 27 in. wide; consequently, the regular drawing board is the double elephant size, with T-square to suit.

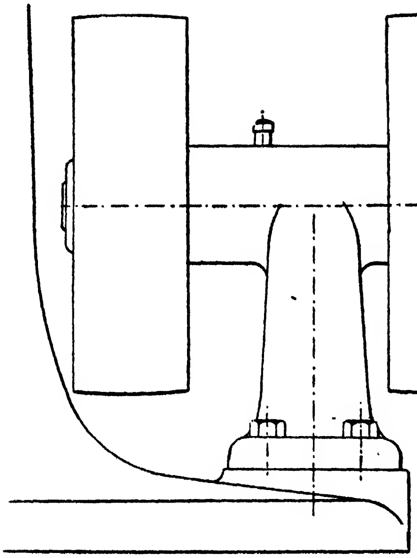
5. HALDEN'S DRAFTING TABLE

Of late years considerable attention has been paid to the development of the board and square, the object in view being to increase the output of the draftsman by decreasing the number of mechanical movements which are necessary to produce a given number of lines, and at the same time to introduce a more healthy position of working than that of half lying on the board.

Universal Drafting Machine. A good example of a time-saving apparatus is the Universal Drafting Machine [4], which consists of a graduated square having an accurate parallel motion about the drawing board; both blades of the square are graduated for drawing and measuring lines at the same time. The blades, or scales, are interchangeable, and are supplied in any length and with any scale desired. With this machine it is possible to draw lines and scale them at the same time, both horizontally and vertically, thus eliminating scales and set squares as separate tools.

The machine is readily set at any angle, and consequently in angular work the comparative convenience and saving are much greater. The drudgery part of the work is removed, thus saving time and leaving the mind more free for the art of designing.

Drawing Boards. The usual drawing board is placed either flat upon a table or is slightly angled by packing blocks underneath. If it is packed up to a sufficient angle to relieve the draftsman from the cramped position of bending over it, the squares, tools, etc., slide off the board, and in the endeavour to obviate these defects a number of ingenious drawing tables have been put on the market. A modern, well-designed and well-constructed apparatus is illustrated in 5. The T-square is

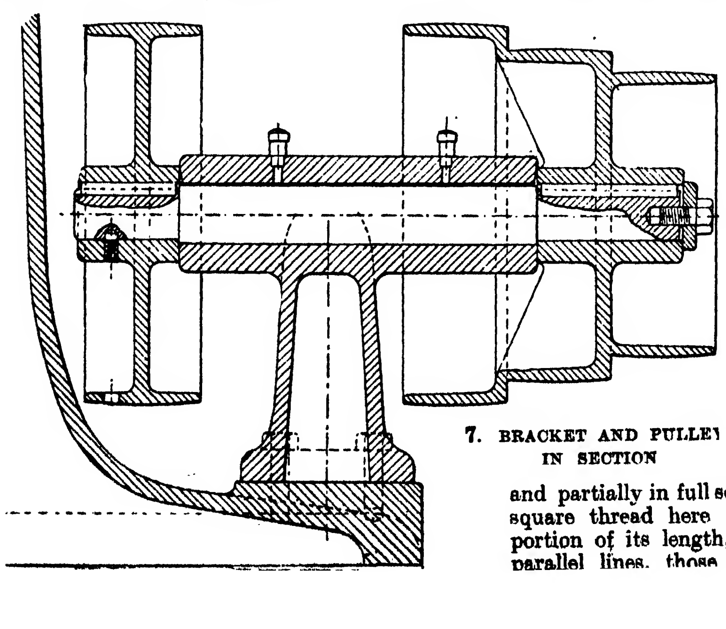


6. BRACKET AND PULLEYS IN EXTERNAL ELEVATION

replaced by a straightedge which can move either in a dead parallel line or at any reasonable angle, the board is arranged upon runners, and can be raised or lowered to suit the draftsman; when in its highest position the table beneath can be used for calculations, writing, etc., the runners in turn are hinged and can be readily set at any desired angle for convenient working; drawers are fitted in the table for instruments, etc.

Elevations and Plans. For whatever purpose a drawing is made, it is rarely sufficient to give simply a single view of an object; shafting may be so dealt with on a detail drawing, but the majority of objects demand two or more elevations, a plan, and perhaps several sections. Elevations and plans may be simply external views of an object, with or without dotted interior work, or they may be sectional views showing the internal work in full lines, or they may be half sectional and half external. Again, considering general arrangement drawings, it is permissible to show an elevation or a plan with a portion of the machine removed in order to better depict the internal work; in this way cover-plates or foot-plates may be omitted or broken away so as to give greater clearness to pipes, gearing, lever work, and so forth, which would otherwise be dotted. Inverted plans or underneath views are sometimes desirable. Sections are not always absolute—that is, although a view may be justly termed a section, it will generally have some portion of it in pure elevation. For instance, a section cut through a bolted joint would invariably show the bolts in external elevation, or, in the case of shafting passing through bearings or pulleys in section, the shaft would not be shown in section. A section may be developed upon a diagonal line or even upon a zigzag line if a clearer idea of the work may be thus obtained.

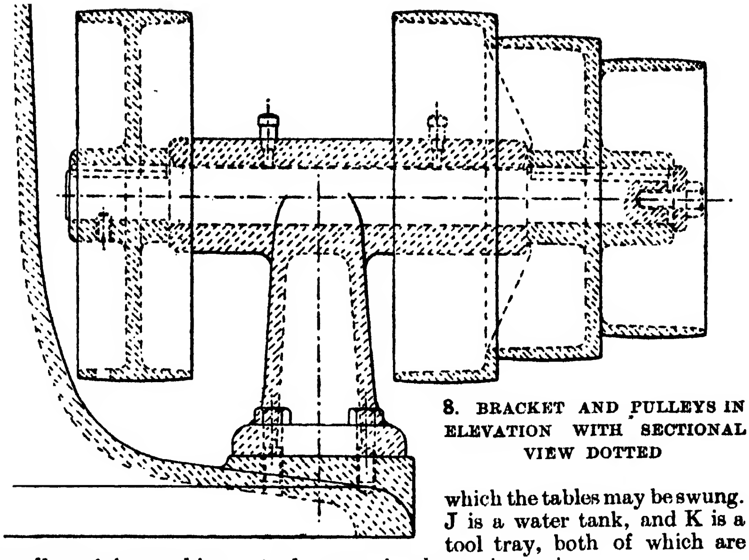
Examples of Drawings. The following examples illustrate some of the foregoing remarks: 6 shows a bracket and pulleys in external elevation, 7 shows the same work in section, while 8 shows it in elevation with sectional view dotted. It will be noticed that a certain distinctness or relief is obtained by making some lines thicker than the others; this is based upon the assumption that light strikes the object from the top left-hand corner, leaving all the top and left-hand lines of a thinner character than the lower and right-hand ones. The centre lines are shown chain dotted to distinguish them from the ordinary dotted lines; the V-screw threads in the full section are indicated by alternate thick and thin lines, the thick ones being the shorter of the two and representing the small diameter of the thread; these threads again in the dotted sectional view are shown by parallel lines indicating the top and bottom of the thread.



7. BRACKET AND PULLEY IN SECTION

tion and dotted section, and partially in full section is shown in 9. The square thread here is clearly indicated for a portion of its length, the rest being shown by parallel lines, those representing the base of

the thread being dotted. The centre spindle is shown in external elevation although the surrounding work is in section; a portion, however, is broken away and shown in section so as to let the key for the hand-wheel be indicated more clearly. The head of the tightening or holding-down bolt has diagonal lines shown thereon, indicating that the head is square in plan.

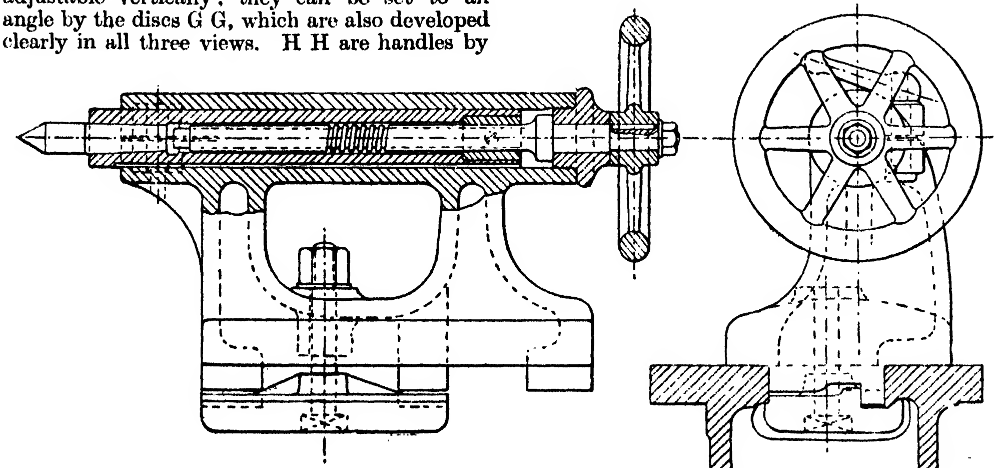


8. BRACKET AND PULLEYS IN ELEVATION WITH SECTIONAL VIEW DOTTED

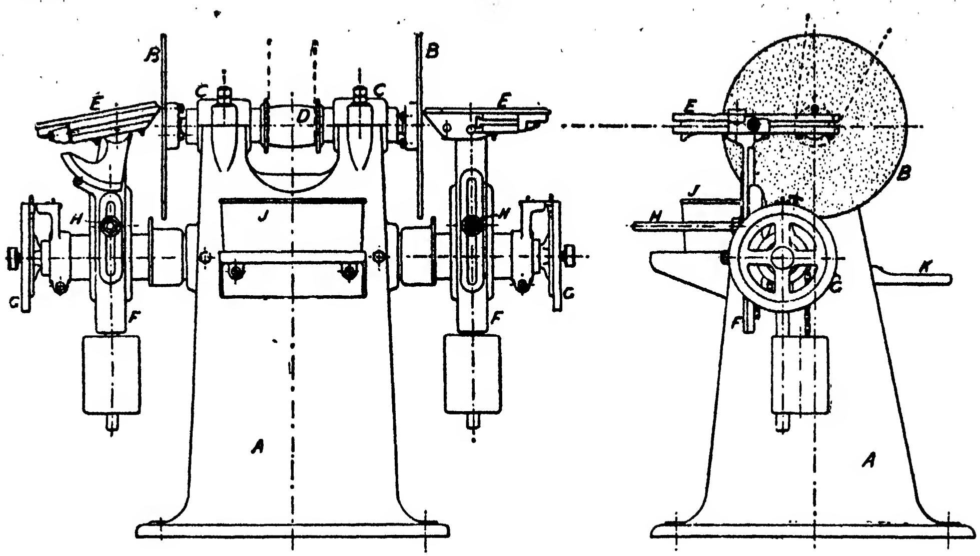
Drawing a Disc Grinder. Three views of a disc grinder are shown in 10. It will be seen that it is necessary to compare one view with another in order to obtain a correct appreciation of the form and disposition of any detail, as well as of the machine as a whole; the reference letters thereon will facilitate this comparison. The stand A would require two or more sectional views to give an idea of its interior. The discs B B are shown in the end elevation together with the disposition of their holding-on screws; their distance apart, their thickness, and their bosses are indicated in side elevation and in plan. C C are the caps for the spindle that carries the discs; the plan view gives additional information to the side elevation. D is the belt pulley which, being circular, does not require many views. E E are the tables for supporting the work to be ground. They require all three views to give a correct idea of their form; they are arranged to tilt and they have protractors for setting to angular grinding as shown in the plan view. The supports F F which carry the tables are adjustable vertically; they can be set to an angle by the discs G G, which are also developed clearly in all three views. H H are handles by which the tables may be swung. J is a water tank, and K is a tool tray, both of which are to be seen in the various views.

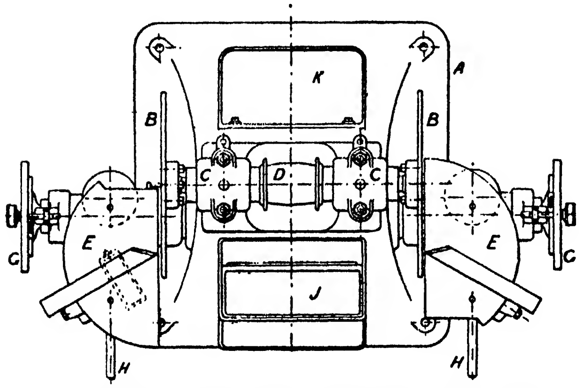
Value of Drawings. The exact number of views required of any particular machine or object depends upon the complexity of its form: the objective to be attained is so to depict and dimension it as to leave no room for doubt in the mind of the workman as to its true form and dimensions.

A drawing is a form of written language which must be expressed in as clear and concise terms as possible; it is a language, too, which has its idioms and conventionalities, which will become apparent to the student as he progresses in the art. For instance, sections are either cross-hatched or coloured in a distinctive manner so as to indicate the various materials employed; the practice of colouring a drawing is not so prevalent as it was before the advent of phototype printing, and the now wide



9. LATHE POPPET PARTIALLY IN EXTERNAL ELEVATION AND DOTTED SECTION AND PARTIALLY IN FULL SECTION





COMPARATIVE VIEWS, ELEVATION, AND PLAN OF A DISC GRINDER

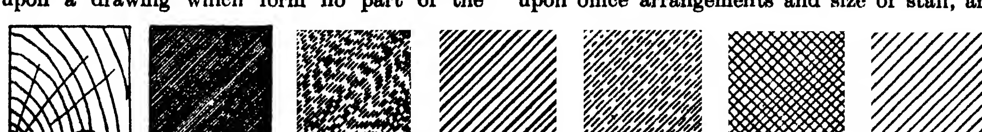
adoption of the ferro-prussiate process, consequently the cross-hatching of sections has received more attention. The usual cross-hatchings in practice are shown in **11** (A—F). The usual colours are as follows:

Steel	Violet carmine.
Wrought iron ..	Prussian blue.
Cast iron	Neutral tint.
Brass	Gamboge.
Timber	Burnt sienna.

Frequently sections are simply cross-hatched as in **11G** and the name of the material written thereon.

Dimension Lines. There are many lines upon a drawing which form no part of the article itself, but are still very necessary; the centre of any symmetrical body is always located by a line of distinctive colour or formation; such a line is termed a centre line, and it forms a most convenient basis both for the construction of a drawing and also for dimensioning. This applies not merely to the larger portions of a machine, but down to each and every bolt and rivet. These lines, again, are very often reproduced upon the machine itself, forming bases of measurement for the correct location of shafts, gears, bolts, etc. Dimension lines are also a necessary adjunct to a working drawing and are also shown in a distinctive colour or formation; the word, of course, explains itself, and it would appear a simple matter to cover a drawing with dimensions. But the placing of a dimension line upon a drawing demands experience if that dimension is to be a useful one, and in this connection it is necessary for the draftsman still to look at the drawing from the point of view of the workman; he must place himself in the position of the patternmaker and figure on the dimensions he would require in order to make the pattern; he must place himself in the position of the blacksmith or forgeman and give them the necessary figures. And so in turn with platers, boilermakers, machinists, fitters, and so forth.

Drawing and Tracing. The procedure followed in making a drawing depends largely upon office arrangements and size of staff, and

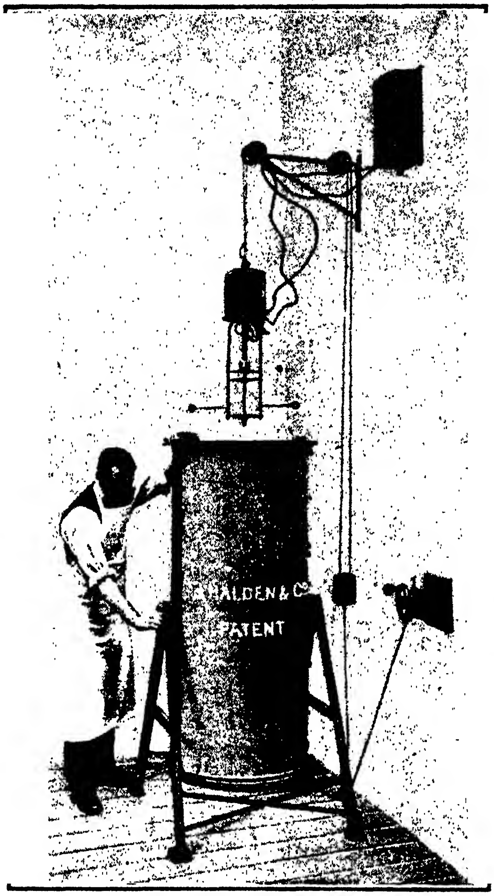


A. Timber B. Cast Iron C. Steel D. Wrought Iron E. Brass F. Lead G. General

11. METHODS OF INDICATING VARIOUS MATERIALS

both of these vary considerably in different establishments. The days when a draftsman inked in his drawing and carefully shaded and coloured it are distinctly past; economic division of labour, together with the advent of phototype printing has resulted in the draftsman leaving his drawing to be traced by lower salaried members of the staff. The drawing is, however, completely finished in pencil—*i.e.*, lines are properly dotted where necessary, all centre lines and dimension lines with dimensions and notes are figured on; it is then handed to a junior to be traced. This done, it is checked and sent to the photo department to be printed. When a draftsman inks in his own drawing or traces it, he does not finish it so completely. In the pencil stage, for instance, dotted work is shown in full lines and no dimensions or notes are figured on; this is, of course, simply to avoid useless repetition of work.

Colours and Inks. Another time-saving element is the use of liquid colours or inks. The time honoured device of wasting half an hour a day in rubbing down inks and colours finds no place in the modern office; there are plenty of reliable liquid inks of various colours now on the market and they are distinctly cleaner and more uniform to use. Black is, of course, the standard colour for the ordinary lines, and some firms prefer to use it for centre and dimension lines as well, as it gives the best printing results. In such cases these lines should have a distinctive form or dotting in order to prevent confusion. Brick red, carmine, and indigo give very good printing results and may be used for centre and dimension lines.



12. ELECTRIC COPIER

Printing. Reference to phototype printing has been made, and a short note upon the subject will not be out of place. Broadly speaking, there are three processes in vogue—*viz.*, black line on white ground; blue line on white ground; white line on blue ground. The latter process is the simplest, cheapest, and most generally used, but has the great drawback that it will not show colours properly, the ground being blue. The first named is the nearest approach to the literal reproduction of a drawing, but it requires more care during the process and demands a more perfect tracing; a crease or dirt mark is printed readily. It has, however, together with the second-named process the great advantage of being colourable. Prints are made in either daylight or electric light; the latter is the usual method as weather and seasons do not interfere with the work. The regular type of machine [12] consists of a cylindrical glass frame into which an arc lamp descends at any pre-determined speed, the tracing is laid on the outside of the glass cylinder with the sensitised paper outside of that again; cloth covers are then closed over and fastened, current is switched on, and the lamp lowered by automatic gear at the required speed. Upon completion the print is removed, treated to chemical or water baths as required, and dried off.

Continued

Group 25
HEALTH
2
Continued from

THE FINANCE OF HEALTH

Life Shortened by Ignorance, Carelessness, and Wilful Neglect. Bankruptcy. Living too Fast. How Strength Varies

By Dr. A. T. SCHOFIELD

LET us now turn to a brief and comprehensive view of ill-health.

Ill-health is when the balance, the equilibrium of destruction and repair, is lost; and the weight in the scale of life is greater on one side than the other—generally on the side of destruction. When it is entirely on this side, and repair has ceased altogether, the result is death. But this is when life, which in this sense is mind, is gone, and all movement therefrom has ceased.

Causes of Death. There are over 1,000 varieties of ill-health, or diseases, though there are only three ultimate causes of death—failure of the nervous system, or *coma*; failure of breath, or *asphyxia*; and failure of the heart, or *syncope*.

Thirty years ago a great many diseases were thought to be non-preventible which are now being constantly prevented. Among them, we may mention all the infectious fevers, including typhoid and cholera, as well as consumption, and sometimes cancer. Indeed, it is now difficult, if not impossible, to point to one absolutely non preventible disease.

Why, then, do eight out of nine people still fail to live out their days and die before their time? Why does the average expectation of life stand at 43 years instead of 75 or 100?

How Life is Shortened. There are at least three great reasons—ignorance, carelessness, and wilful neglect in general, and especially of the five laws of health.

Ignorance of these simple laws in their application to the individual is still very common among the so-called educated classes as well as among all other members of the community.

Carelessness, to which, besides many diseases, nearly all accidents and infectious fevers are due, is found everywhere, and is of a very different type from the wise carelessness that makes for health.

Wilful neglect is, of course, the most sinful of all, and amounts morally to suicide, or even to manslaughter when it results in death, and it takes on its most repulsive form when it is the means of infanticide. It has been pointed out that the most fatal of the three is wilful neglect; carelessness being less so, and ignorance, with which is allied superstition and quackery, being least fatal of all. It is unspeakably sad to think that some 200,000 die prematurely every year in this country from these three causes, and that some 7,000,000 people are needlessly ill. What a loss this is to a nation's wealth may be computed when we remember that the average value of a man is £158 1s. 6d.

The Laws of Health. The five laws of health are, as we know, good food, pure air, cleanliness, suitable dress, and proper exercise and rest. What strikes one immensely is the extreme simplicity of these hygienic precepts.

We all know them, but it is probably true to assert that not one single reader of these pages can say he has kept them; nay, further, that there is no reader but can distinctly recall, if he takes the trouble, some occasion when ill-health has arisen from the clear infraction of one of them. It is one thing to know, quite another to do; and health consists in the latter. Granted that at first sight the predisposing causes seem beyond our power to prevent; but, inasmuch as we must ever remember that they merely weaken our resisting power, and never in themselves absolutely produce disease, there is no reason whatever, apart from exciting causes, why ill-health should ever arise from them.

Health and Age. Age has a good deal to say to health, as the following remarkable table shows.

DEATHS PER 1,000 OF THE POPULATION PER ANNUM

	4-12 years	12-20 years	20-34 years	34-54 years	54-74 years
Male					

This table is well worth a moment's thought when we consider that it applies more or less all over the world, affecting millions of lives—for about 70 are born and die on this globe in each passing minute. It will be observed that the deaths during the first four years of life nearly equal those during the next 70 years; in other words, that one year before the fourth year of life is as dangerous as 70 years after.

If a child can live till it leaves the nursery it has a chance of growing up; a mortality of 70 under four dropping at once to six when over four. A human being never again enters such a fatal period as the nursery until he is over 74 years of age. And why? Because in infancy, when the child can do nothing in the way of self-preservation, ignorance, carelessness, and wilful neglect reign supreme, and the results are awful.

A young baby's life is as easy to snuff out as a candle, and 12 under four are lost each year for every one over four—for by this time the organism is hardier and better able to resist the carelessness with which it is still surrounded.

There is no doubt that from the time growth ends till old age begins—a time of some 30 years or so—should be a period of special good health, the organism being then free from diseases of growth or degeneration. The two changes in life at about 15 and 45 are times when some special care is often needed with regard to health.

But if, during this 30 years, health is firmly established as a habit, the latter period need not be feared.

Effects of Habit. Habit counts for much in health, and when all the organs of the body have worked well together for years, they become hardy, like seasoned veterans, and can go anywhere and do anything.

During growth, however, not only the body but the character is being formed, and if under four the dangers are chiefly due to the indiscretion of parents or nurses, after that age they become increasingly due to one's own folly—a constant source of danger.

Finally, then, our endeavour should be first to live out our days and die a natural death, and, secondly, to keep our health while we live.

Not, let it be repeated, that either life or health are ever to be the *object* of our lives. At best they are but *means* to higher and worthier ends, and anyone short-sighted enough to make them the goal of life will lose one, if not both, of them. No man is in health who lives to preserve his health, but that man is in the best health to whom his God is first, his neighbour second, and himself last.

Health Finance. The bringing of the language of the counting-house to bear on the question of health may prove of great value to our readers. Stereotyped language, familiar phrases, oft-repeated maxims, soon lose their power, and fail to effect any good. Their very familiarity obscures the force of their meaning. Utter them in some novel way, or in some foreign tongue, what power they have! How much more imposing psychotherapy is than mind-healing, cardiac than heart, gastralgia than stomach-ache, hygiene than health. Small manuals abound on every bookstall and in every shop; but if we are to arouse our readers to such a serious consideration of these matters as can really benefit them, we must seek to put old truths into new language, and use fresh means to impress familiar facts upon the mind.

No doubt when we observe multitudes suffering from the results of *ignorance*, *carelessness*, and *wilful neglect*, our sympathies lie mostly with the ignorant, and it is truly pathetic to see the numbers that become *health bankrupts* solely and entirely from their ignorance of the merest elements of finance.

It is, indeed, this piteous spectacle of seeing not only the poor, but the educated classes in midnight darkness respecting the most elementary health questions, simply because their boasted education left off at this most vital point, that moved the author to devote himself for some years almost entirely to the cause of health teaching, and to seek so to extend the curriculum, especially in girls' schools and women's classes, as to include the vital subject of hygiene. When we think how easy it is to acquire sufficient sound knowledge on this subject to be of real use, we must all feel that no education is complete that does not include *a practical knowledge of personal and domestic hygiene.*

Health and Wealth. What, then, is meant by "Health Finance"? It is the application of commercial language to the principles of health. It is to write of the *common health* in terms of *commonwealth.* It is to understand that wealth consists rather of health than money, even for the rich, while it is the sole wealth of the poor.

It is, indeed, in this class that this pathetic ignorance culminates. No child plays with money more foolishly than many men play with health; no spendthrift is more reckless with his dollars than many are with their life-force, and while with the rich the resulting ill-health may have its terrors mitigated and compensated for by material wealth, with the poor it means veritable and literal bankruptcy, for the ill-health which proclaims the health failure is also, in the breadwinner, the cutting off of all power of earning money. Our ordinary language, to some extent, expresses the parallel between health and wealth, for when we talk of a "poor" creature, we as often mean one in bad health as in great poverty. The phrase denotes equally well a deficiency of strength or of money.

"Health Finance" embraces a knowledge of what in life constitutes *capital* and *income* and *expenditure*, and some idea of the current rates of living. It brings home to us our extravagance in various ways, while it also shows the folly of some sorts of parsimony.

Foolish Economy. The difficulty that we try to guard against in writing on this subject is to avoid transforming some of our readers into what may be called "health prigs," or valetudinarians. Just as a person is intolerable, and is rightly despised, who is ever talking of how carefully he lives within his income, and how particular he is about every penny he spends, so is a man equally objectionable who won't do this or that because he is full of ideas that he is spending too much life-force, and who thus becomes a veritable hypochondriac.

Such action can only be the result of a rank abuse, and never of the wholesome use, of this section. The subject must be dealt with, because this knowledge is still so much needed, for although health manuals abound, their maxims are not followed, and they, one and all, treat of the *body only*; while we shall always endeavour to speak of the *man as a whole*, including in this term very specially *woman*, as being, after all, the one who is principally interested in personal hygiene.

Let the wise reader, then, carefully read and assimilate the facts here presented to him, and make up his mind whether he is going to live on a sound financial health basis or not. Some of our greatest men and women deliberately accept the latter alternative, and lay down their health, and even their lives, for the sake of

serving others. To such be all honour, but for the bulk of our readers it is wisest to answer "Yes," and, having done so, to find out, in general terms, how to apply the principles to their own individual lives.

The first thing then to do is to cease to worry about one's health, and to live with that wise carelessness of which we have already spoken—the outcome of a healthy spirit, and the pledge of a healthy body. A carelessness springing from knowledge differs in every respect from that which results from ignorance—the one is *wise*, the other most *unwise*.

Bankruptcy. We now pass on to questions of bankruptcy. When capital runs low, and the individual is conscious that his stock of reserve force in any particular body system is dwindling, he probably seeks, first of all, to stave off ruin by stimulants of various sorts according to the part most drained. If the nervous system is giving out, he tries to recuperate it by powerful nerve tonics; if the circulatory, by strong heart medicines; if the digestive, by all sorts of patent and digestive foods and pepsin pills; if the locomotor, or muscular, by electricity, massage, and the like, and so on. Or he may very foolishly fly to alcohol, a stimulant that only makes further drafts upon what little capital may be left, for it never adds to the reserve energy, but, like a whip to a tired horse, forces us into activity by using up our resources.

The other systems may still have reserve force to spare, and yet the man as a whole may break down through weakness of one of the chief systems. Of course, if the failure be absolute, *death* ensues; if only partial, *ill-health*. It matters not, as we have said, whether we are egoistic, squandering our capital on ourselves, or altruistic bankrupts, spending it on others—the result as to health is the same. If the failure be only partial, we become ill, and fall into the doctor's hands; and, if he be wise, he does not leave us just when we are able again to meet current expenditure, but insists on our replacing our spent capital and storing up our reserves—very expensive and trying work. To replace lost muscle by special treatment costs at present about *four or five guineas a pound*, while nerve and heart force are at least as costly! When we remember that with the poor health is their only wealth, it is easy to see of what vital importance it is to them that their reserves be not trenched upon, for their chances of replacing them are very remote.

We have already suggested in this connection that we have to do with different sorts of people, as well as of expenses. We may now consider these in a little more detail.

Differences in Income. In the first place, there are men and there are women, and the latter in strength are (or were until recently) to the former as, roughly, 5 is to 8. In this ratio, if the income of the former be 320 foot-tons (a ton raised a foot) a day, that of the latter in equal health would be 200—a considerable difference, showing at once that no real general competition with man is either possible or desirable by woman.

Then, again, some are naturally rich and some poor, and the former have great advantages over the latter—advantages they may either use or abuse. The rich have not to use up all their energies in earning health incomes, and the result is they are much more free to spend them as they wish. If, then, the person and his objects be good, this freedom that wealth gives is a benefit; if they be bad, it is an evil—all depends on the man. The disadvantages of the poor we have already spoken of; they are piteous enough, and exist whether the person be good or evil.

Some, again, are rich in one sort of capital and poor in others. That is, they may have strong heads and weak hearts, or sound stomachs and congested livers, and so on. The great object with these should be to know exactly the system which is most likely to become bankrupt, and try and make that system equal in strength to the other—as, for instance, the respiratory system in those born with weak chests, with no reserve force to resist disease.

Men and women, again, are made with very different health dispositions, some being born spendthrifts, others born financiers, ready to make the best use of all they have.

Effects of Occupations. Occupation, again, has a great bearing on the health expense of living. In the English nation, the proportions of some of the leading classes of occupations are as follows:

There is, first, the professional class, numbering some 7,000,000, whose health expenses are great.

Second, the domestic class, mostly women, about 6,000,000, whose expenses are less.

Third, the commercial class, of some 800,000, who, again, have to spend much.

Fourth, the agricultural class, of some 1,600,000, who can live economically.

Sixth, a non-productive class of children, women, and idlers, of 7,500,000, whose health expenses should be low. Generally speaking, five-sixths of the community are materially poor, and one-sixth are rich.

The *health expenses*—as well as the people themselves—must vary much. Brain and heart work are both costly, and all unhealthy work involves great expense. Of course, there are different sorts of expense, according to the particular system that has to pay the bill; and an effort should be made by the man who owns all these systems to save the expenses of the poorer and weaker ones, and make the richer and stronger systems pay. How to do this we shall see better in detail further on.

Not only, however, can special economies always be exercised, but general economies as well; and hundreds of labour-saving appliances help us to this in the present day.

In short, without penuriousness and undue carefulness, a watchful eye should generally be kept on the health expenditure, and any unavoidable runs on the bank through ill-health, caused, maybe, not from financial indiscretion, but through some invading horde of microbes, should at once be stopped.

Women should understand these things even more than men, not only because their income is smaller, but because they have so much more to do with health than men, being mostly born nurses, and having the care of all children.

It is, therefore, of great importance to them that they should have sound, clear views on health finance.

We would again point out that while on the one hand nothing can be more selfish and repulsive than to be always anxious in every detail to avoid spending this income, on the other hand, nothing can be more sinful and careless than to lose a useful life when there is plenty of money in the bank in the other systems simply through carelessness in allowing one vital part to become bankrupt.

Health in Old Age. Some valuable hints have been given us on saving health expenses by men who have reached old age.

Moltke, when asked in his ninetieth year how he had maintained his health and activity, answered, "By great moderation in all things, and by regular out-door exercises." Crispi said that "regularity and abstinence are the secrets of long life." Sidney Cooper, the veteran painter, also believed in regularity; Legouvé attributed his long life to regular exercise. An American nonagenarian, the Hon. Neal Dow, of Maine, laid stress on the careful avoidance of fretting, of disturbance of the digestive organs, and of exposure to sudden or protracted cold with insufficient protection against its influence.

Dr. Jowett told Dr. N. Pope, the well-known Tamil scholar, that "to have a great work in progress is the way to live long." According to Sir James Sawyer, the secret of longevity consists in "paying attention to a number of small details." Among these are the following: (1) Eight hours' sleep; (2) sleep on the right side; (3) keep the bed-room window open all night; (4) have a mat to the bed-room door; (5) do not have the bedstead against the wall; (6) no cold tub in the morning, but a bath at the temperature of the body; (7) exercise before breakfast; (8) eat little meat, and see that it is well cooked; (9) (for adults), drink milk; (10) eat plenty of fat, to feed the cells which destroy disease germs; (11) avoid intoxicants, which destroy those cells; (12) daily exercise in the open air; (13) allow no pet animals in living-rooms—they are apt to carry about disease germs; (14) live in the country if possible; (15) watch the three D's—drinking-water, damp, and drains; (16) change of occupation; (17) take frequent and short holidays; (18) limit your ambition; and (19) keep your temper. Sir Benjamin Ward Richardson said: "The would-be centenarian should never smoke nor drink—especially the latter, and he should eat very little meat. He should keep early hours and work as little as possible by artificial light. Moreover, he should not make haste to be rich, and he should avoid worry and consuming ambition." We do not endorse all these precepts, some of which are but fads, but give them as the sayings of wise men, and as containing a good deal of sound advice.

Avoiding a Breakdown. Before concluding this lesson we must say a little more upon two points—the difference in health-wealth between one person and another, and the best ways of avoiding a health breakdown from a financial point of view.

The *differences in health-wealth* are often the causes of much ill-health. A sees B spending so much energy every day, and at once seeks to emulate, if not to surpass him, forgetful of the fact that B's stock of strength is in every way far superior to his. Many a man and woman would remain in good health and strength, according to their own standards and varieties, as long as they kept to their own spheres. The folly is when the man goes in for violent athletics to which he is not accustomed, or the woman undertakes tasks and responsibilities for which she has never been fitted.

A common instance of this folly is often seen in boys and girls; when the girl accompanies her brothers or father in long, toilsome walks or cycle rides quite beyond her strength, simply because she is ashamed to give in; and thus often starts an ill-health or breakdown that takes years to get over. Keep company then with, and share the pursuits and exercises of, men and women of your own physique and calibre.

Strengthening Weak Organs. The remaining point is the best way of *avoiding a health breakdown* from a financial point of view. This is ensured by carefully noting the one system that is weakest, and persevering until it is made the strongest. It matters not which vital part is the weak one; whether it be brain, or heart, or lung. Once it is known, it is quite possible, and a proof of the utmost wisdom, to set to work and thoroughly build up the strength of this one part, until no special weakness is left in it, and it has powers of resistance at least equal to the rest. This is the way to avert bankruptcy and secure continued health; and here is the value of these lessons. It is by a study of the principles laid down here, by a knowledge of what constitutes weakness, by an understanding of which *are* the vital points for defence on which health really depends; it is, in short, through the knowledge that these three sections, *physiology*, *health* and *ill-health* impart, that one is enabled intelligently to take those simple and yet important steps that secure the health-wealth and prevent bankruptcy. Our desire is above all to be practical, and it is perhaps in this direction that the greatest benefit can result to our readers from them.

We would point out here that this course contains, in addition to many matters of vital importance to one's personal health, all the subjects included in the South Kensington Science Examination, Elementary and Advanced, the County Council Technical Examination, those of the London and provincial school boards, polytechnics, and science teaching centres throughout the kingdom.

Continued

REPTILES AND AMPHIBIA

Crocodiles, Tortoises, and Turtles. Extinct and Extant Amphibia. Cæcilians. Newts and Salamanders. Frogs and Toads. From Tadpole to Frog

By Professor J. R. AINSWORTH DAVIS

REPTILES—continued

Crocodiles and Alligators. These inhabitants of the rivers and estuaries of tropical regions are somewhat lizard-like in appearance [328 and 329], but in structure they are in many ways much more specialised. The snout is armed with powerful interlocking teeth, which constitute a deadly trap. The valvular nostrils are on the top of the snout, so that the animal can drift along with most of its body submerged, and at the same time breathe quite easily. Should it perceive an unfortunate mammal drinking or browsing on the edge of the bank, or an unwary human being in or near the water, it sinks below the surface, and rapidly swims towards the victim by strokes of its powerful, flattened tail. Then comes a sudden snap, aided, perhaps, by a lash of the tail; should the attempt prove successful, the prey is held under water till it is drowned, if too large to be forthwith swallowed.

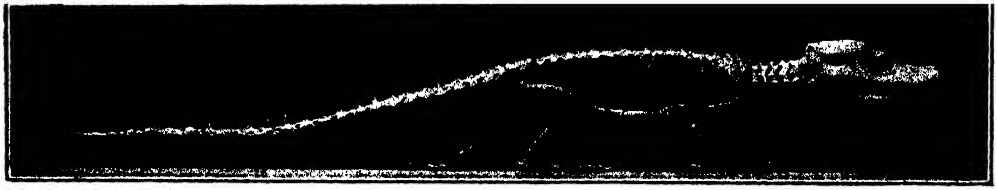
Breathing Apparatus. The crocodile itself is not choked during this procedure because it is in possession of a structural arrangement comparable to those described elsewhere for whalebone whales and newly-born pouched mammals, such as kangaroos. The internal openings of the nose (internal nostrils) are very far back, and the top of the windpipe is drawn out into a projection wrapped round by folds so as to project into them. There is no danger, therefore, lest water, after entering the mouth, should enter the lungs.

In some crocodiles—*e.g.*, certain species inhabiting the Ganges—the food consists of fish, and here the snout is very long and narrow, as in the fresh-water dolphin of the same river. Comparison may also be made with one of the extinct toothed birds (*Hesperornis*) of the chalk period. In all cases a very efficient seizing apparatus results, well adapted to deal with the slippery prey.

328. CROCODILE — *Rudland*

Peculiarities of Structure. There are many other points in which the structure of these reptiles presents points of interest. The body, for instance, is not only clothed with strong, horny scales, of which those on the upper side of the tail make up a saw-edged ridge, but also defended by bony scutes in the skin. The stomach is not unlike that of a bird, part of it being converted into a muscular gizzard, the crushing action of which is enhanced by stones or other hard objects which are swallowed from time to time. The organs of circulation are also of great interest, for the heart is four-chambered, as in mammals and birds, and not three-chambered, as in other reptiles and amphibia. The pure and impure blood do not, therefore, mix inside the heart; but as such blending takes place outside, owing to imperfect separation of the great vessels, the net result is much the same as in the lizards, etc. But it may be said that crocodiles are well on the way to become warm-blooded animals, and they are also more intelligent than other reptiles, in correspondence with the larger and more complex brain which is present.

Tortoises and Turtles. This widely distributed order includes a great variety of forms adapted to live under the most varied conditions. Some are vegetarians, others flesh-eaters, but in all cases the teeth are replaced by a strong, horny covering to the jaws, making



329. SKELETON OF A CROCODILE

up a sort of rounded beak, which is hooked in the carnivorous types.

Remarkable defensive armour is, however, the most characteristic feature. The body is, as it were, sheltered in a strong case, consisting of an upper shield (*carapace*), which is more or less united at the edges with an under shield (*plastron*), to make up a sort of box [330], giving a remote resemblance to the arrangement present in armadilloes among mammals. The outer layer of the case is composed of horny plates, which in certain marine species are the source of "tortoiseshell," and beneath these are bones [333], some of which are derived from the backbone and ribs. At the front and back of this case are deep hollows, into which head, tail, and limbs can be withdrawn. The neck is exceedingly flexible, which compensates (as in birds) for the rigidity of the trunk.

330. CHARLES'S ISLAND TORTOISE *Dando*

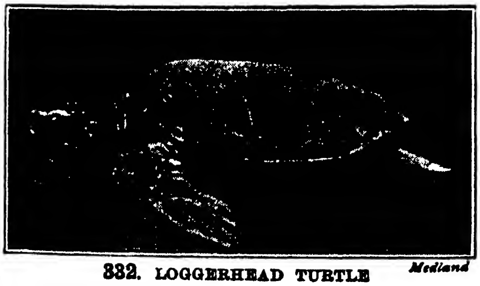
Gigantic Tortoises. In land-tortoises the extremities are stumpy and well suited for progression on a firm surface [330]. It is particularly interesting to notice that, in the absence of severe competition, some of the tortoises living on isolated islands have attained a large or even gigantic size. This applies to some of the islands of the Indian Ocean, and also to the Galapagos Islands, situated on the equator to the west of South America. The gigantic tortoises of the latter were long ago described by Darwin in his account of the voyage of the Beagle.

In marsh [331] and fresh-water tortoises the limbs are more or less flattened out to serve as paddles, and this modification is carried to an extreme in the thoroughly marine turtles [332 and 333], where the limbs are in the form of powerful flippers.

331. MARSH TORTOISE
Photographed by Prof. B. H. Bentley

AMPHIBIA

What Constitutes Amphibia. Frogs, toads, newts, salamanders, and some other cold-blooded, backboned forms are often popularly regarded as reptiles, but in reality belong to a decidedly lower class, the Amphibia. The soft, slimy skin, and the absence of scales and claws are distinctive characteristics of existing members of the class, but a more important point of difference is to be found in the nature of the life-history. A frog, for instance, does not hatch out of the egg as a miniature adult, but as a limbless tadpole, breathing by means of gills and presenting other resemblances to fishes. Later on, this larval form passes through a number of changes, together making up a "metamorphosis," and by which it gradually comes to assume the form and structure of the adult. The fore and hind limbs sprout out, and air-breathing lungs are developed, while, in the frog, the gills entirely disappear. In some other amphibians, however, the gills may persist throughout life.



332. LOGGERHEAD TURTLE *Medland*

Extinct Amphibia. Some of the most ancient extinct reptiles with which we are acquainted possessed certain structural features which ally them to the amphibia, and have no doubt descended from creatures of the kind. And, as might be anticipated, the reptiles in question come nearest to the oldest known amphibia. These were the members of the great order of armour-headed amphibia (*Stegocephala*), the first backboned animals which entered into the possession of the land. They included a great number of forms, some very small, others of great size, which date from the coal period and became entirely extinct during the earlier stages of the Secondary epoch, being apparently unable to compete successfully with the rapidly evolving group of reptiles. The heads of these ancient types, and their bodies, more or less, were protected by an armour of bony plates.

Recent Amphibia. These are grouped into three orders: 1. CÆCILIANS (*Apoda*); 2. TAILED AMPHIBIA (*Urodela*); and 3. TAILLESS AMPHIBIA (*Anura*).

Cæcilians are limbless snake-shaped forms, which burrow in damp earth, and are widely distributed in the tropical regions of both hemispheres. Their distribution, and the fact that they are devoid of any means of rapid dispersal, suggest that the group is one of great antiquity.

And, as a matter of fact, these little creatures, although in some respects much specialised, come nearer the primitive extinct forms than the other existing amphibians. Numerous little bony plates, for example, are imbedded in their skin, representing the armour that was once characteristic of the class.

Tailed Amphibia. Most country dwellers are familiar with the little efts, or newts, commonly to be seen in ponds or ditches or crawling over the damp ground in their vicinity. In appearance they are not unlike lizards, but their movements are much more sluggish, while the slimy, scaleless skin and the clawless digits at once show them to be amphibia. The limbs sprawl even more than in reptiles, and the thumb is absent [compare 338]. Besides this, newts lay their eggs in water, and tadpoles hatch out from them. Our largest native species is the great crested newt (*Triton cristatus*), which is so called because, during the mating season, the male possesses a saw-edged fold or crest placed in the middle line of the upper side of the body.

Poisonous Types. Salamanders resemble newts, but are mostly larger [334], and when adult, better suited for a life on land. The spotted salamander (*Salamandra maculosa*), common in damp woods in parts of central Europe, is black in colour, with orange blotches, giving it a very striking appearance. It is, in fact, a case of warning colouration, for a poisonous fluid exudes from the skin (as in most amphibia) which is highly distasteful to mammals, and if injected into the blood of small animals of that class proves fatal. An enterprising lady who investigated the matter gently pressed the tail of a salamander between her teeth, and experienced considerable swelling of the mouth and tongue, associated with the distressing symptoms of temporary dumbness.

The acquisition of poisonous properties by the skin has doubtless enabled amphibians to dispense with the armour they once possessed. These properties are no doubt the foundation of the superstition with which newts, frogs, toads, etc., are regarded, but as they neither bite nor sting, and can be handled with impunity, and since in addition they wage unremitting war upon various small pests, there is no excuse for regarding them with antipathy.

333. SKELETON OF A TURTLE

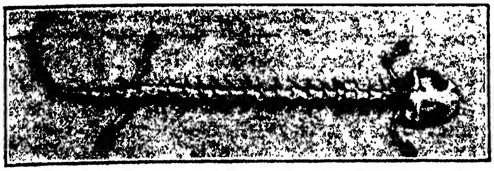
Egg-laying Larvæ. It is interesting to note that the tailed amphibia are characteristic of the northern hemisphere, within the limits of which they are represented by very numerous forms. The giant salamander (*Cryptobranchus japonicus*), of Japan and China, is the largest of these, being about 6 ft. in length [334]. But probably the most interesting member of the order is the creature known as the axolotl, of which a living specimen is here represented [335]. It is an aquatic form native to Mexico, and possesses not only lungs, but red plume-like gills projecting from the side of the neck. The eggs are laid in water after the usual fashion of amphibians. A good many years ago it was discovered that, under certain conditions, axolotls kept in captivity lose their gills and change into a kind of salamander [336], and we now know that this takes place naturally in the southern part of the United States. The axolotl, then, as such, is neither more nor less than a permanent larva, which has precociously acquired the power of laying eggs and, in Mexico at least, dropped the adult stage out of its life-history.

Many of the lower species of tailed amphibians retain their gills partly or entirely throughout life, this being naturally associated with an aquatic habit. Such forms are common in North America, and there is one curious species, the olm (*Proteus*), which inhabits caves in the Austrian province of Carniola.

Tailless Amphibia. These include frogs and toads, which are the most successful members of the class and are to be found in almost all parts of the world. On examining a common frog (*Rana temporaria*) [337], we at once notice the short, tailless body, and the disproportionately long hind limbs, characteristics associated with the leaping habit. These points are even more obvious in the skeleton [338], which should be compared with that of the giant salamander, a tailed form [334].

The frog is also an expert swimmer, and the hind feet are webbed. They execute movements closely resembling those employed by human beings for the same purpose, but the fore limbs take no part in aquatic progression, being folded on the breast.

The mottled skin of a frog in many respects harmonises with the surroundings, and serves



334. SKELETON OF GIANT SALAMANDER

the double purpose of protection and aggression. A large amount of change of colour can take place, somewhat as in the chameleon, but less rapidly and without so extensive a range of possibilities. Such changes are rendered possible by the presence of innumerable minute star-shaped cells (colour bodies) in the skin, which contain a dark pigment. Under the action of the nervous system these may be contracted to mere pins' points in size, or expanded to relatively large dimensions. In the former case the pigment is reduced to a small area, and the skin assumes a light, yellowish-green hue, as it does among grass. This state of things is reversed when the colour-bodies enlarge, as happens when frogs lurk among dark surroundings.

Insect Catchers. The insects which make up a large part of the food are captured by means of the long, sticky tongue, as in chameleons; but here the mechanism is somewhat different. The tongue is attached to the front of the floor of the mouth, and, in a state of rest, its forked tip points backwards down the throat. When brought into action the free part of this organ sweeps upwards and forwards out of the mouth, its end brushing past the roof of the mouth cavity, taking up some of the sticky fluid discharged by a group of small glands. The prey secured, the tongue is rapidly drawn back to its former position.

337. FROG
Photographed by Prof. B. H. Bentley

From Tadpole to Frog. Frogs and all tailless amphibians breathe entirely by the lungs and skin, the gills and gill-slits of the tadpole being entirely lost in the adult. The life-history of the frog, which presents us with the best practical illustration of evolution, is represented here by a set of figures [339]. The little limbless tadpole which hatches out from the egg possesses a large swimming tail, and breathes by three pairs of plume-like gills, much like those of an axolotl. Later on these are replaced by the so-called "internal gills," : vascular folds on gill-slits which place the cavity of the throat in communication with the exterior. A fold over gills (which are shrivelling) and the gill-slits, its edge fusing with the wall of the body, except at one place on the left side, where a small round hole ("spiracle") is left for the exit of water which has entered the mouth, traversed the gill-slits, and bathed the gills for the purposes of breathing. Meanwhile, the lungs are growing out as pouches from the under side of the back of the mouth floor, and begin to share the work of respiration, gradually supplanting the gills, which ultimately disappear, while the gill-slits close. These alterations involve profound changes in the heart and blood-vessels. To begin with, the heart is essentially like that of a fish, consisting of two principal chambers—an *auricle*, which receives the impure blood of the body, and a muscular *ventricle*, which pumps it to the gills for purification. After this it is distributed to the body at large.

338. SKELETON OF FROG

336. SALAMANDER
Photographed by Prof. B. H. Bentley

The Lungs and the Heart. As the lungs begin to act they pour pure blood into the auricle, which becomes divided into two by a partition, the left moiety (left auricle) receiving the pure blood in question, and the right (right auricle) acting as a receptacle for impure blood. As the ventricle remains undivided, the two kinds of blood it receives from the auricles to some extent mix in its cavity; but, owing to its spongy wall and several other structural features, the mixing is only partial. The result is that, in the adult animal, impure blood is pumped to the lungs and skin, pure blood to the head, and mixed blood to the rest of the body.

335. AXOLOTL
Photographed by Prof. B. H. Bentley

From amphibia upwards to reptiles, birds, and mammals, evolution has brought about a gradual perfecting of the arrangements for keeping pure and impure blood separate. But only in birds and mammals is this end completely attained, and the whole of the body supplied by perfectly pure blood. Hence the success of these two classes of backboned animals.

Other striking changes mark the conversion of a tadpole into a frog, and of these the most obvious are the gradual absorption of the tail and the growth of fore and hind limbs [339]. While the young tadpole is a vegetarian, the adult frog is highly carnivorous, and the long spirally-coiled intestine of the former is in marked contrast with the relatively short, convoluted intestine of the latter.

Paternal Care of the Young. Our native frogs and toads do not trouble themselves about the well-being of their eggs and young, but this is far from being the case in all members of the order. The male of the midwife toad (*Alytes*), native to parts of Europe, carries the egg-strings round his legs until they hatch out, and takes the greatest care lest they should dry up. Much more remarkable are the arrangements in a South American species, in which the male possesses a pair of membranous croaking sacs, which primarily serve as resonators to increase the musical effect of the voice, under the skin of the under surface. Into these pouches the just-laid eggs are introduced, and the entire development there takes place, the young remaining in this curious paternal nursery until they have assumed the adult form.

Considerable maternal solicitude is shown by some members of the order. In the Surinam toad (*Pipa*), for instance, the eggs are placed on the rough skin of the back, within cavities of which they pass through their development changes. In other cases (*Nototrema*) there is a pouch in the skin of this region which answers the same purpose. Many tree-frog mothers construct nests in which to deposit their eggs, the most remarkable case being that of the South American ferreoir (*Hyla faber*). Here the female builds a circular mud wall in the shallow part of a pond, within which the eggs are laid. A considerable part of the life history is passed in this neat and comparatively safe "nursery." The success of many tailless amphibians in the struggle for existence is partly due to their possessing strong parental instincts, which gives their offspring a better chance of survival.

339. FROM TADPOLE TO FROG
Radiographed by W. Morley Martin

The Struggle for Existence. In a certain sense it may be said that amphibians occupy the same sort of place in the animal world that ferns and the like do among plants. For in both cases there is more or less dependence upon moist conditions during part of the life-history, a sort of memento of the purely aquatic life led by remote ancestors. This is somewhat of a handicap in the struggle for existence. An amphibian is obliged, so to speak, to "fight on a double front." The tadpole competes with aquatic forms, the adult with terrestrial ones, or both. There is some compensation for the latter, however, as it is often able to use the water as a place of refuge.

The destruction of insects, etc., by frogs and toads, already noted, is perhaps the best illustration of the economic uses of amphibians, though the hind legs of frogs are largely eaten abroad, and decidedly excel chicken in delicacy of flavour. Their skins are employed to some small extent for ornamental purposes. Nor must it be forgotten that scientific investigations on the frog, "the martyr of science," have led to many results of great value in physiology. It is hardly necessary to say that there is no "precious jewel" in the head of the toad.

Continued

THE HUMAN INTELLECT

How We Reason. The Functions of Perception and Conception. Character, Reason, and Will. Reason is Independent of Character

Continued from page 2696

By Dr. C. W. SALEEBY

BEFORE we proceed to inquire very closely of what reasoning actually consists, we may note the conditions upon which it depends. Previous sensation, of course, is necessary. There can be no reasoning without experience; and in the last resort the reason is always limited by experience. Then, of course, memory is absolutely necessary. We could not utilise experience in reasoning if it had all "passed in at one ear and out of the other." Not only the retention of experiences is necessary, but also the power to recall them.

A Necessary Condition of Reasoning. Thus, the association of ideas is a necessary condition of reasoning: before very long we shall see that it is much more. Necessary also for the power of reasoning is the possibility of what we may know as abstraction. Consider: You are sitting in your chair thinking about something. Whether on a higher or a lower plane, you are probably reasoning in some degree. If you are reasoning very intently, trying, for instance, to solve some insoluble puzzle in psychology, your companion will be apt to say that you are absent-minded. All sorts of sensory impressions are possible—sensations from your interior, from your clothes, from the chair, from the light in the room, from your friend's voice, from the cigarette in your mouth; but, in fact, *you* are far away. Plainly, you have the power of abstraction. Present experiences are as nothing. The real self of you is concerned elsewhere. Of course, we do not always assert that one is reasoning when one is absent-minded, for to think of a friend across the seas is to have the power of abstraction; but if there were no such power we could not reason.

Five Men in Five Worlds. The more we know the more profoundly do we realise the truth that man is a being of a "large discourse, looking before and after" ("Hamlet"). In virtue of this power of the mind, man is not tied to the present; he has memories and imaginations. Five men may be sitting in one and the same room; one of them, a thinker, is really living at the moment in the world of ideas. The musician next him is living in a world of sound—as Beethoven did when, although stone-deaf, he produced some of the greatest of his immortal works. The artist next him is conceiving a colour scheme of new beauty. The mathematician is in the world of numbers, while the cricketer next him is forcing a good-length ball past cover-point. Such is the power of abstracting the self—the power in virtue of which man is ever independent of present circumstances. Surely it is obvious that if one had always to be concerned with present sensations, reasoning would be impossible. Even in bed, in silence and the dark, the self could not think, but would have to be concerned with sensations of touch.

Perception. Again, if we were unable to manipulate our sensations, we should be unable to reason. But the mind has a power of abstracting—to use the word in another sense—certain factors of sensation, and making them into a whole. This power is best described as *synthesis*, a Greek word meaning "placing together." It is obviously the opposite of an equally important power of the mind—the power of analysis, or loosening apart. Now, when one receives visual impressions of a certain shape and colour and unites them so as to enable one to say "that is a brass fender," one is exercising the power which is technically known as *perception*. Many a valuable essay might be written on the profound difference between vision and perception, between seeing and perceiving. In these days we constantly abuse our noble language, so that invaluable verbal distinctions become obliterated. We are all tarred with the same brush, since we all have to read contemporary literature. Our only hope is in the study, as often as possible, of English of the great period, and pre-eminently of the incomparable English of the Bible. The translators of Isaiah recognised the distinction which the present writer is trying to enforce: "And he said, Go, and tell this people: Hear ye indeed, but understand not; and see ye indeed, but perceive not." (Isaiah vi. 9). This is rendered even more emphatically when quoted in St. Matthew xii. 14: "But hearing ye shall hear, and shall not understand; and seeing ye shall see, and shall not perceive." This splendidly significant antithesis is actually quoted three times in the New Testament.

The Growth of Perceptive Power. The growth of the power of perception may be recognised in the child. To use the common, clumsy speech which we all employ to-day, when a new object is presented to the child, he "sees it but does not see what it is." In other words, though vision be perfect and though the whole of the object be seen, it is not perceived: the child is as yet unable to make that psychical synthesis which constitutes the act of perception. Surely we have made our point clear. But if not, let us consider the case of a puzzle picture. You look at the stupid thing and turn it upside down, and this way and that, yet cannot make out where the face is hidden. You see the face the whole time; the fault is not in the eye. At last, however, you say "I see it," by which, of course, you mean "I perceive it." You have, at length,

made the necessary psychical synthesis, and the lines which seemed before to represent nothing but the aimless parts of a tree are now perceived to constitute the well-known lineaments of the face for which you were looking.

Such a psychical synthesis is quite distinct from what the doctors unfortunately call *word perception*. When a certain part of the brain is injured one can see print but cannot understand it. The visual apparatus is intact, but the apparatus which attaches a symbolic meaning to the black marks on the paper is injured. Reading, however, does not depend upon a psychical synthesis, or perception in the proper psychological sense, but merely upon the arbitrary attachment of certain symbolised meanings to certain inky symbols.

Conception. We now know what the process of perception means, and how it differs from mere sensation. Properly speaking, we must call the process *perception*, and the result of the process a *percept*. Higher than this is the process of *conception*, and the product of this process we call a *concept*. The words are used in common speech in an adequate sense, and do not need much further study. The definition of Professor James is this : " The function by which we mark off, discriminate, draw a line round, and identify a numerically distinct subject of discourse, is called conception." Now, it is with concepts that we reason.

It has already been stated that the association of ideas accounts for the power of recollection, and the meaning of the phrase has been described in the authoritative words of James Mill. But we must now return to the subject, since we have to learn that the association of ideas plays a very great part in the reasoning or rational or intellectual processes. Let the reader consider what he actually does when he *thinks* or reflects, or when he is engaged in rational conversation or discussion with a friend. If there were no power of recollection, which depends upon the association of ideas, or if these associations proceeded without meaning or reason, then would there not be something very like loss of reason or insanity ? Or, when these associations proceed upon the surfaces of things and insist more upon apparent than real resemblances, then if there be any gift of expression as well, have we not the materials for a humorist?

The Most Wonderful Material Thing We Know. Not so very long ago the association of ideas was described in terms which we are now inclined to regard as meaning very little and explaining nothing. For instance, in our quotation from James Mill on page 2259 the word *idea* is used in a manner which would scarcely be permitted now. There was no explanation of the association of ideas until the psychical fact was correlated with the neural fact—that is to say, until some correspondence was found between mind and brain. We shall never understand the association of ideas nor the conditions which make reasoning possible unless we have some adequate knowledge of the structure of the brain. The only part of the brain, practically, with which we are concerned is the great brain, or cerebrum. This is covered with grey matter which is filled with nerve cells, and beyond all question it is this grey matter that must be regarded as the most wonderful material thing in the whole universe so far as we know it.

Compartments of the Brain. Now, modern study has shown that the grey matter on the surface of the cerebrum may be marked out into areas, the functions of which can be detected. We are positively acquainted, for instance, with the motor area of the cortex of the brain, with the visual area, the auditory area, the area concerned with smell, and so on. Nevertheless, there remains a large part of the surface of the brain, most especially in the region of the forehead, to which no such definite function can be allotted. This failure to discover the function of so much of the brain is in reality not a failure at all. These areas, which we are now learning to call *association areas*, cannot be connected with any function of movement or sensation, for the very excellent reason that they have no connection with any such function. Their duties are far higher and more subtle. From all of these areas of association and from all the other areas of the brain there proceed hosts of nerve fibres which pass to every other part of the brain. Directly or indirectly, all the parts of the brain are interconnected with all the other parts. No one who has the smallest acquaintance with the anatomy of the nervous system can question for a moment that the psychological fact which we call *the association of ideas* corresponds with facts of the anatomy of the brain.

The existence of association fibres is one of the most remarkable and significant facts in the anatomy of the brain, and is seen to be so the more closely they are studied. While they are found everywhere, certain great bundles or strands of them may be distinguished, and to some fifteen or twenty of these, names have been given. They are found to occur especially just where they might be expected, intimately connecting the areas concerned with all the most important functions, while, in addition, each association area is closely and abundantly connected with all the others.

The Mechanism of Association of Ideas. The existence of these association fibres must be clearly distinguished from that of what are called the *commissural fibres*. These latter are very abundant, and their business is to connect one side of the brain with the other. No doubt they have ultimately a similar function, but the great significance of the association fibres proper is that they do not merely connect the two halves of the brain, but that they run between all the various parts of each half. Given these facts, can we conceive the mechanism of the association of ideas ? Of course, various theories have been advanced, and at the present day we need consider only theories which fully allow for our recently acquired and very detailed knowledge of the internal structure of the brain. Dr. McDougall says : " Not very long ago psychologists who sought a physiological

basis for mental retention were content to assume that the persistent nervous change, which is the essential condition of the revival of an idea, was some change in what they called a 'ganglion-cell;' meaning thereby the nucleus-containing body of a nerve-cell. And an association was conceived as a nervous channel connecting two such 'ganglion-cells,' so that, when one of them is excited, an 'impulse' travels along this path to the other, and on reaching it, causes it to give out its idea as a bell gives out its note when struck. This conception was, in fact, suggested by Hume, one of the first to treat of the association of ideas."

Dr. McDougall goes on to point out certain objections to this view, and certainly it has its difficulties. Nevertheless, if we are to have any rational interpretation of the association of ideas in the light of the undoubted facts of brain organisation, it is some such notion as this that we must accept. Assuredly we cannot conceive that one nerve-cell or ganglion-cell can contain an idea. We must think in thousands, rather than units, but this is merely a modification in the details of the theory.

Unconscious Reasoning. To identify mind with consciousness in the sense in which the latter word is usually employed is to commit a fundamental error. That there is such a thing as unconscious reasoning can scarcely now be questioned. The results of such reasoning may come up into consciousness at a required moment. If we conceive of association in the old terms there is no room for explanation of any unconscious or subconscious processes of reasoning or association. But if we conceive of association in something like the language which has been quoted, we are able readily to understand how associative processes may go on independently of the will or consciousness in the ordinary sense. There are a thousand examples of this. For instance, one forgets a name and strives to remember, and fails; minutes or hours later, and apparently quite by chance, the lost name suddenly "pops up" into consciousness. This, of course, is not an example of reasoning, but it is an example of the process upon which reasoning depends, and the sequence of events that result in the sudden emergence of the desired name can be explained by some such theory as has been described, though it is absolutely unintelligible if we are to confine ourselves to the language in which the association of ideas was "explained" three-quarters of a century ago.

The Function of Reason. The place and function of reasoning in human life are very commonly misunderstood. Defining the ideal of a liberal education, Professor Huxley says: "That man, I think, has had a liberal education . . . whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth, working order. . . ." This precisely expresses the proper function of reason in man. It is entirely erroneous, when using such a phrase as "the dictates of reason," to conceive of the reason as being the dictator of the will. The reason is merely a machine, a method, or *organon*, which enables us to reach a given end. The reason, as such, has no motor power, nor influence upon the will. Given a certain motive—as, for instance, the desire to reach a given place—the reason merely supplies the will with the information necessary for the most convenient effecting of its purpose. As the present writer has said elsewhere, "the mainspring of willing is wishing, is desire. *We act because we want*, and our reason is not the driving-shaft but the rudder. The reason, to vary the image, is not the breeze, but the pilot." The reason drives us nowhere, but merely directs the forces that do drive us. Its function is directive, and not motor.

We are Ruled by our Emotions. Every psychological truth, every fact of the human mind, has an intimate and immediate bearing on human life. It is the belief of the man of science and the philosopher that all facts whatsoever have a bearing upon human life, and plainly none can be so important as the facts of human nature itself. These few words regarding the function of reason may, perhaps, appear superfluous or merely academic to the reader, yet they enunciate a truth which is totally ignored, and which is of cardinal importance in the most vital of all our duties, that of education. It is commonly believed that man is a rational animal in the sense that if you educate his reason and give him plenty of information about which to reason, he will act accordingly. But men are not determined by their reason. The mainspring of action is the emotional nature, and it follows that, since the object of all education is to influence action, our efforts should first be devoted to the development and training not of the reasoning but of the emotions and the will. It does not suffice to teach a boy that it is wrong to steal, nor when he disappoints us, to blame him. We should have turned our primary attention not to his reason, but to his emotions, "it being better to steer an unskilful course to a worthy goal than to take the shortest and quickest road to perdition. . . . When a man is a knave at heart, it is well for his neighbours if he be a fool to boot." These psychological truths mean that the supreme end and aim of education is character-making, since it is the character and not the reason that determines conduct.

Reason and Character. Another delusion—one of the many that are to be found in the popular beliefs about the reason—is that the conclusions of the reason are determined by the moral nature of the individual, and more especially the conclusions of the reason upon matters of religion and morality. All churches in all times have tended to regard disbelief in their dogmas as indicative of moral disease, assuming that only such moral disease could cause disbelief. This is a perfectly fallacious assumption. In so far as the reason is what it should be—that is to say, a logical engine—its conclusions are entirely unaffected by anything but the nature of the fact that is reasoned about. They are not in the least determined by the moral character of the individual, by

his natural desires, or by his early upbringing. In none of its conclusions should the reason be affected by such circumstances any more than it is so affected when seeking to estimate the truth of a proposition of Euclid.

Moral Character and Beliefs. If we desire instances of the disastrous consequences that have flowed from the ignorance of these psychological truths, we need only turn to the history of the greatest of all evils—religious persecution. The noblest character of the ancient world was Socrates, the very founder of the science of morals. His splendid intellect led him to certain conclusions different from those held by the authorities of his time. As we say nowadays, he had "peculiar views on religion." He disbelieved in the old gods, and dared to say so. Arguing on the assumption that a man's beliefs are not products of a cold logical engine, not even in the case of the wisest, but reflect his moral character, the Athenians condemned and killed Socrates as impious, immoral, and a corrupter of youth. What a lesson for all subsequent ages!

The reader will not think us irreverent if we remark that the Founder of Christianity was put under a similar condemnation by a similar argument. He rejected certain beliefs, and therefore it was said that He must be wicked. The early Christians had to meet the same charges, and often to die for them. And there are so-called Christians to-day who are incapable of thinking that beliefs different from their own can be held by any but immoral and dissolute persons. Psychology, then, has this most important lesson to teach, as a standing protest against all who consider that a man's moral character may be estimated by his beliefs—that the conclusions of the reason, in so far as they *are* rational, are determined by only two factors: first, the data which are submitted to the reason; and, secondly, the nature of the reasoning process. [See LOGIC.]

The Pursuit of Truth. It has been extensively argued that there are no rational conclusions in this sense, and that all our beliefs are determined by other factors than those named. And in many matters it is indeed evident that a man's temperament influences his belief; but if we turn to some abstract subject, such as mathematics, the conclusions of which scarcely affect a man's happiness, we readily see that it is possible to hold rational beliefs, defined as we have defined them. They are determined solely by the nature of the facts in question and by the nature of the logic engine. Any mathematician who could be detected as holding certain beliefs because he had himself laid them down on a previous occasion, or because they differed from those held by an enemy of his, would be dismissed as, in so far, no philosopher or lover of truth. And this teaches us what should be the ideal of all rational processes. We must be prepared to follow truth wherever she leads, determined that we shall serve her without fear or favour, and shall not permit our prepossessions or prejudices or desires to influence us in the slightest degree. Says Professor Tyndall: "There is in the true man of science a desire stronger than the wish to have his beliefs upheld—*viz.*, the desire to have them true."

The Supremacy of Reason. This doctrine of the supremacy of reason can be let go only on one condition. This condition is that we deny the existence of objective truth. In our own day there are many philosophers who declare that—slightly to modify the words of Hamlet—"nothing's either true or false but thinking makes it so." But if we believe that this is an unqualified lie, and that truth is truth whatever we think of it, we must allow that reason must not be fettered in its processes by any hope or fear or wish or prejudice of the reasoner. It is those who have followed such principles that we now crown as the kings of thought—the makers of intellectual progress. The others, who have prostituted their powers of reasoning in the service of their prepossessions or their party or their sect, remain as melancholy examples of the lamentable uses to which reason can be put when it is made the servant of the will, and allows the will to dictate to it what it falsely asserts to be its own conclusions.

The Will. And now, plainly, we must turn to the supremely important subject of will. It has already been introduced. We know what is meant by reflex action, and we have declared that the two great classes of acts are the *sensation reflexes* and *voluntary acts*. We have also looked at the most important subject called *inhibition*—that power of self-control by means of which the higher levels of the nervous system are enabled to inhibit the reflex activities of the lower levels. According to Spencer, the first student of the History of Mind, the human will has been evolved from reflex action, and there is probably no pure physiologist—at any rate, none now living—who questions this doctrine. On the other hand, there is much to be said for the opposing view which we have already attributed to Wundt. But, for our present purpose we may simply assume that there is a large measure of truth in both of these views, and that, as we have already hinted, they are not irreconcilable; and we may pass at once to the more practical aspects of will. We have insisted already that the source of will is not the reason, but is the emotional and wishful nature. This is a fundamental truth which relegates the reason to its proper place, and lays the due and supreme emphasis upon character.

Continued

THE POST OFFICE SERVICE

The Importance of the Service. Employment in London and the Provinces for Learners, Sorters, Clerks, and Postmen

NATIONAL SERVICE continued from page 2767

By ERNEST A. CARR

THE Postmaster-General is the greatest employer of labour in the Kingdom. The staff of which he is the official head numbers in all 192,454 persons, of whom about one-fourth are women. This giant force includes both established Civil servants, male and female, and an unestablished section comprising messenger boys, supernumerary postmen, temporary officers, and others whose terms of employment do not confer any right to a pension.

There is scant use in enlarging upon the variety and volume of work performed by the Post Office in all its ramifications, extending from the village shop counter where stamps are retailed to the huge headquarters of the department, which are among the show places of our capital. We are all more or less familiar with that work in its details, and the total results can be stated, indeed, but not really apprehended. To be told, for instance, that 4,479,400,000 postal packets are conveyed by the Post Office every year, and that 88,969,000 telegrams pass over its wires, merely bewilders the imagination with ... e, after all, no

department has grown with amazing speed. The evolution of railways, the introduction of penny postage, and the acquirement in 1870 of virtually all telegraphic systems, owned until then by private companies, have marked the most striking stages in a development that has been practically continuous throughout. A further great extension will occur in 1912, when the whole of the London Exchange area of the National Telephone Company, with its staff of at least 15,000 employees, will be added to the province of the Postmaster-General.

Despite the cheapness and efficiency that characterise Post Office work, this great national service, far from being a charge upon the country, produces a handsome annual profit. On the transactions of the last recorded year there was a surplus of nearly 5½ millions sterling.

Among certain sections of the staff a feeling prevails that some part of these profits might justly be applied to raise the rates of pay, which they contend are inadequate. In several recent instances they have convinced the Postmaster-General of the justice of their claims and have received substantial concessions. At the time of writing a Committee of Inquiry is sitting whose recommendations are expected to lead to some further increases of salary.

Our concern, however, is with existent conditions of service alone. And, in view of the very considerable feminine element in the Post Office staff, we may usefully prelude our detailed study of the various appointments by a few words on the regulations specially affecting women.

Women as Post Office Servants. The Post Office service is distinguished from all other Government offices by the great number of females it employs. In district branches much of the counter and telegraph work is performed by girls and women; the Central Telegraph Office provides occupation for more than a thousand female telegraphists; and other sections of the headquarters staff possess a strong contingent of girl clerks and sorters.

Women engaged on the establishment of the General Post Office—as in other State departments—are under the same general rules, and are entitled to pensions on exactly the same scale, as their masculine colleagues. They are subject, however, to one important disability. Except in the case of the postmistresses, who are especially exempted, female officials must be unmarried or widows, on ...

served for not less than six years receive, when quitting the service in order to be married, a special Treasury gratuity. The amount of this wedding gift is fixed at one month's pay for every completed year's employment up to a maximum of twelve years. A clerk earning, for instance, £84 a year would be entitled after six years' service to a marriage gratuity of £42, after nine years to £63, and after twelve years or longer to £84.

A candidate for a permanent appointment on the Postmaster-General's feminine staff—whether in London or otherwise—must be at least 5 ft. in height. She is generally required, also, to reside either with her parents or guardians or with friends of whom they approve.

London and Provincial Services. The general staff of the Post Office, in all large towns as well as in the metropolis, is largely recruited by the appointment of learners of either sex, who are trained in telegraphy and counter duties. The London service includes also a number of male and female sorters attached to the central and district offices. It should be specially noted that in respect of each of these grades, three distinct methods of making appointments are adopted. The first and most important is that of open competition. For the others the nomination of the Postmaster-General

is essential, the candidates approved by him competing among themselves for vacancies or having merely to pass a test of efficiency. Either mode appears to be employed indifferently, according to the requirement of each office or district; and aspirants will hardly need to be reminded that the wicket-door of nomination is an easier means of entrance than the thronged gateway of a public contest.

The Civil Service Commissioners decline to give any information as to the means by which nominations for the posts of learner and sorter in the Post Office can be obtained. It is certain, however, that private influence with the Postmaster-General is not essential. The likeliest method of succeeding is to enlist the good offices of the district postmaster or other official on whose staff the coveted vacancy arises. For candidates who are unable to secure a nomination the public contests are always available.

The Examination for Learners. Open competitions for these berths are held once or twice yearly, in London and at each provincial town where vacancies exist or are expected. The conditions of duty for London learners and their rates of pay differ slightly from those obtaining in provincial offices, but the examination subjects are identical. Indeed, for all learnerships throughout the Post Office service—whatever the sex of the candidate or the mode of filling appointments—a single examination scheme is prescribed by the authorities. It is of the simplest character, comprising only the following three branches:

1. English composition, including writing and spelling.
2. Arithmetic. English and metrical weights and measures, reduction, vulgar and decimal fractions (excluding recurring decimals).
3. General geography, with special reference to the British Isles.

A total of at least half marks is necessary in order to qualify.

At the open competitions the general limits of age are 15 and 18; but for posts in Edinburgh, Dublin, and certain other towns, boys only are admitted at 14½ years. Nominated candidates may enter until the age of 25.

MALE LEARNERS

The same standard of height—namely, 5 ft.—is fixed for these officers as for female Post Office servants, but by a curious regulation male learners are further notified that they will not be retained in the service unless they reach 5 ft. 4 in. by the age of 19.

The London Staff. From 15 to 40 London appointments are publicly contested each half year or so, and attract considerable notice. Occasionally there are ten times as many competitors as vacancies offered, but the average numbers are four or five to one. Successful candidates attend for eight hours daily, receive instruction in telegraphy and afterwards in counter duties during about a year, and are paid 8s. a week meantime. While under tuition their mav be cancelled if they show no proper aptitude for the work. They are liable to do Sunday work and sorting duties, and on reaching the age of 18 will be called upon to do night-work when requisite. As vacancies occur, proficient learners are appointed to the established staff at a salary of 16s. a week, either as telegraphists at the Central Telegraph Office or as counter clerks and telegraphists in the London postal service, from which moment their service begins to count towards a pension. After a year their weekly pay becomes 18s., and at the age of 19 it is increased to £1. From that figure it rises every year by 2s. 4d. a week, with a special increase of 3s. at the age of 25, up to 44s. a week. An officer who obtains "a certificate of excellence of conduct and ability to perform the highest duties of his class" continues to advance by yearly increments of 2s. 4d. a week to the maximum rate of 62s.

In both branches of the London service these officers are eligible for promotion to certain higher appointments, relatively few in number, ranging from the grade of overseer, at £190 a year, up to that of inspector or superintendent, with a salary of £350 or £400.

Provincial Posts. Male learners in provincial centres are trained much as in the London service, but their wages, both before and after promotion to the establishment, vary slightly in the different towns, and are generally rather less than in the capital. Beginning at 6s. or 8s. a week, and rising to 10s. the second year and 14s. the third, they become sorting clerks and telegraphists as vacancies occur. At the age of 19 their pay is 18s. a week, and in certain towns 19s. Thence it progresses each year by 2s. weekly (with a special additional increment of from 1s. to 2s. 6d. on reaching the age of 25) to 40s. 6d. or 41s. 6d.; and, if a certificate of conduct and ability is obtained, to a maximum of 50s. to 56s. a week, according to the size of the town. Meritorious officers have also good chances of advancement to the positions of assistant-controller, superintendent and provincial postmaster, with remuneration varying from £180 to £600 a year.

FEMALE LEARNERS

The age limits and examination scheme for these posts being the same as those for men, and the general conditions of service very closely similar, a few words will suffice for such differences in respect of pay and other matters as call for comment.

Open competitions for vacancies as female learners have lately been held in May or June of each year, and are a good deal more keenly contested, as a rule, than those available to the other sex. At one examination for 15 situations in London no fewer than 354 candidates entered, only 56 of whom failed to qualify. But, as a rule, the number of vacancies is considerably greater than on this occasion and the competition proportionately less severe.

Except that women, while liable for Sunday duty, are not called upon to perform night-work, the mode of instruction and hours of duty

are the same for female as for male officers; but the rates of pay, although they have been recently improved, are still a good deal less. Female learners in the London branch are paid 7s. a week on entry, and 10s. 6d. when certified as competent for telegraph instrument duty. After a year's service at this figure, if still less than 19 years old, they receive 14s. weekly, at which rate of pay they are promoted to the established class as vacancies arise. When a year's service on the establishment has been completed, the salary of officers under 19 years of age becomes 15s. 6d. By a special provision of the Postmaster-General, every member of the London service, whether promoted or not, receives from her nineteenth birthday the "age pay" of 18s. a week. From that salary, established clerks advance by annual increments of 1s. 6d. weekly to 28s., and, on obtaining a certificate of proficiency, to 38s. a week. They are also eligible for higher posts at £130 a year and upwards, but these are relatively few in number.

In provincial towns slightly lower rates prevail both for learners and for established clerks. The salary appointed by the regulations for officials of either class on their reaching the age of 19 is 15s., or, in some cases 16s. weekly. Officers on the establishment receive, as in London, annual advances of 1s. 6d. a week; but the maximum attainable varies between 33s. and 35s. There are also further possibilities in the way of superintending positions and appointments as postmistress, few of them exceeding in value £200 a year.

MALE SORTERS

About half the vacancies arising in the ranks of the male sorters are regularly reserved for limited competition among postmen, telegraph messengers, and other subordinate members of the London Post Office staff. They must be nominated to compete by the heads of their departments, and in this way promotion is given to deserving and intelligent officers. The remaining situations are filled by means of open competitions, held twice or thrice yearly for a varying number of vacancies. The greatest number of places offered in any recent contest is 104, and the smallest five. Although not of greater value than learnerships, these posts attract more competition, probably because they carry a higher initial salary.

Candidates must be between 18 and 21 years of age, with the customary allowance of not more than five years to those who have been employed in the Army, Navy, or Civil Service. They must be at least 5 ft. 4 in. in height, and physically fit for the proper discharge of their duties. Apart from specific ailments, constitutional weakness or want of general vigour may disqualify a candidate from receiving an appointment.

The examination subjects are precisely the same as for Post Office learners, given above. Our table shows the marks recently gained by the first and last successful candidates among 306 who competed for 25 sorterships.

EXAMINATION FOR MALE SORTERS

Order of Merit.	English Composition (including Writing and Spelling).	Arithmetic.	[illegible]	Total.
Maximum	1,000	500		1,900
No. 1	869	468	270	1,607
No. 25	754	464	244	1,462

Pay and Duties. Sorters who are less than 19 years old when appointed receive 18s. a week until they reach that age, when they are paid 20s.—the salary at which those who enter at 19 or later begin. From this point the rate of advance is exactly the same as for London ex-learners—namely, annual increments of 2s. 4d. weekly (with an extra increase of 3s. at the age of 25) to 44s. a week, officers who are certified as fully proficient going on to the special maximum of 62s. There are also a moderate number of higher positions rising to £200 and £290 a year.

These officers are on probation for the first year, and are employed chiefly in letter sorting, in which subject they must pass a test within a few months after being appointed. They do eight hours' duty daily, sometimes beginning early in the morning or late at night. Sunday work counts as extra duty, and is paid for at special rates.

FEMALE SORTERS

Some 700 female sorters are employed in various departments of the London General Post Office. Their duties relate, not to letter sorting, but to arranging vouchers and counterfoils for the clerical staff. They work for the same number of hours as their male colleagues, but under less trying conditions, being engaged only between eight in the morning and five in the afternoon; and they are exempt from Sunday duty. The wages paid begin at 14s. weekly, and rise by 1s. a week for two years, and afterwards by 1s. 6d., to 30s. a week, subject to a special certificate of ability when 21s. 6d. is reached.

The age limits for these situations are the same as for learnerships, and it will be seen that they are approximately of the same value as London posts of that class—at least, during the earlier years of service. But the work is more monotonous and uninteresting, the maximum attainable is 8s. a week less, and there are very few higher posts for which sorters are eligible. Further, the examination, simple as it is, comprises the learners' subjects and an extra one besides—that of reading and copying manuscript. Apparently, however, these objections are more than outweighed by the certainty of fair and progressive earnings from the outset, instead of the learner's small allowances and her uncertain chances of a vacancy on the establishment. The result is that the open contests for female sortership—held, as a rule,

each April and October—are thronged with candidates in the ratio of a dozen or a score to every vacancy, and the proportion of marks necessary for success rises sometimes to almost 90 per cent.

FEMALE CLERKS

Just a quarter of a century has elapsed since a former Postmaster-General decided to admit a few women clerks to the ranks of his headquarters staff. So successful did the venture prove that to-day, apart from those who have entered as learners, there are no less than 1,930 ladies employed at the G.P.O. on a special clerical footing. Of this number, 1,788 hold permanent positions as women clerks, the remaining 142 being of the temporary order of girl clerks.

Unlike learners, members of these two classes are never called upon to do duty in the local post offices, nor, indeed, to come into contact with the general public in any way. They are employed in a private and strictly clerical capacity in certain of the central departments—chiefly in the Savings Bank. Among the attractions of their service are short hours of duty, pleasant work, and an assured prospect of at least £100 a year. Seeing how overcrowded and underpaid are the ranks of the women clerks in commerce, it is not surprising that these Government berths are eagerly sought.

The senior and the junior grade are separately recruited by means of open competition; but the examinations for both classes are held simultaneously, the subjects prescribed are the same, and, in fact, the papers set are identical for each, though the lists of candidates and the results are kept entirely distinct. As a rule, contests for both girl clerks and women clerks are held twice yearly—in March and October. In order to qualify, half marks must be obtained.

Examination Subjects. The schedule of marks and subjects given below relates to the most recent of these dual competitions whose results have been published. It shows the marks secured by the highest and lowest successful candidates alike in the women's and the girls' section.

A few words may be added as to the character of the examination. The paper in geography is always largely concerned with the physical and industrial aspects of that study, and generally includes a sketch map, the insertion of details in a printed outline map, and several questions on the natural wealth and manufactured products of various countries or districts. The language tests comprise only translation from and into the foreign tongue. Only two languages may be offered, and in the great majority of cases the choice falls on French and German. Candidates who take shorthand are required to take down three passages read aloud at the respective rates of 60, 72, and 80 words to the minute, and afterwards to transcribe their shorthand notes.

Girl Clerks. Appointments of this class are in themselves of a temporary nature, and are intended to furnish suitable training for the senior and permanent grade. The examinations are restricted to girls between 16 and 18 years of age. Some 20 to 30 vacancies are offered at each examination, and though the number competing is sometimes ten times as great, the *effective* competition is far slighter, as frequently less than half the candidates reach the qualifying standard. In the contest for 25 appointments to which our table relates, only 100 out of 236 entrants gained half marks.

Girl clerks are only employed as such for a term of two years, performing six hours' duty daily, and receiving £35 the first year and £37 10s. the next. At the end of that time, those who are certified as competent are promoted, as vacancies occur, to be women clerks. Girls who fail to obtain a certificate of competency are appointed as female sorters, retaining their current salary. For a clerk of ordinary intelligence and application, however, advancement to the senior grade should be a matter of course.

Women Clerks. The age limits for these posts are 18 and 20, and therefore a student who reaches the former age without having gained a girl clerkship can transfer her efforts to the senior grade without the slightest loss of time or change of work.

OPEN COMPETITIONS FOR GIRL CLERKS AND WOMEN CLERKS

Order of Merit.	Engl ion (Spel			Two Only.				Two Only.		Total.
Maximum	800	600	500	500	500	600	500	500	500	3,900
Girl Clerks:										
No. 1	560	305	291		340	324		425		
No. 25	595	492	297			204	197	336		
Women Clerks:										
No. 1	588	500	379		327	377	374		413	
No. 35	544	517	265		245	189	277	268		

Women clerks are required to do seven hours' duty daily. On entering the service, they are appointed to the second class at £55 a year, and receive annual rises of £2 10s. for six years, and then of £5, to £100. On promotion to the first class the salary becomes £105, rising by £5 to £130. Beyond this class there are in all about 100 higher positions, culminating in that of staff superintendent at £320 a year, advancing to £450 or £500. Thanks to the way which the ranks are depleted by marriage, a first-class clerkship at least may

be anticipated by those who remain in the service.

At one time these posts were keenly contested, but for some reason—possibly connected with the advent of the typewriter and the consequent increased demand for women clerks in the commercial world—the number of candidates has been steadily declining of late. The contest of which particulars are given above was attended by only 132 women, of whom no more than 79 succeeded in qualifying. These figures may be commended to the notice of young women in search of an easy and settled calling.

TELEPHONE OPERATORS

The Post Office telephone service gives employment to a large number of women, who are officially styled "telephone operators." At the London Telephone Exchange no fewer than 668 of these officers are engaged. In the London service they are paid 7s. a week when appointed as learners. On their becoming efficient operators and reaching the age of 17, their wages, starting at 11s. weekly, become 14s. after the first year, advance in the next three years to 20s., and afterwards, on proof of thorough efficiency, to 26s. a week. In the provinces the pay of competent operators begins at 10s. and rises to 18s., with a higher grade as in the London branch.

The nomination of the Postmaster-General, which is required for these situations, is readily given to suitable candidates between the ages of 16 and 19. A simple and non-competitive test in reading and copying manuscript, writing, spelling, and the first four rules of arithmetic, must then be passed. Finally, applicants must satisfy the authorities that they are medically fit, are free from hysteria or excessive nervousness, and have neither impediment of speech nor strongly marked accent that might prevent their being readily understood over the wires. It may be added that to women of highly-strung nerves the operator's life, with its perpetual accompaniment of electric bell ringing, is peculiarly trying.

JUNIOR CLERKS

A number of junior or third-class male clerkships in the General Post Office are reserved for competition among established officers who have served for at least two years in that department, and are between 19 and 26 years of age. In order to obtain the requisite nomination of the Postmaster-General, such officers must be specially recommended by their chiefs as fitted for clerical duties.

The appointments in question arise in various branches of the central office, and are not of uniform value; but they are all sufficiently attractive in respect of increments and prospects to be worth the attention of eligible sorters, telegraphists, and subordinate officers of similar rank. In the secretary's office they begin at £100, and rise by £10 yearly to £200, with an excellent prospect of £300 and chances beyond. In most of the other departments third-class clerks start at £80 a year and progress by increments of £7 10s. to £200, with further possibilities about equal to those afforded by the secretary's branch.

A score or more of these posts are usually contested each March and September. As deserving officers are nominated with some freedom, the number of candidates for each vacancy has been, in one instance at least, as many as 12, but is usually about half that number. The examination is in English composition (with writing and spelling), arithmetic, geography, two languages (the choice being among French, German, and Latin), and two of the following subjects—English history, mathematics, and shorthand. In the last of these papers, the test passages are usually read at 68, 80, and 100 words a minute.

POSTMEN

For the London and the provincial service alike postmen are nominated singly by the Postmaster-General, and have to pass only the simplest of qualifying examinations—which is dispensed with in the case of candidates holding second-class Army certificates. For other entrants the subjects are writing, addition, and reading and copying a number of lithographed postal addresses of very moderate difficulty. The limits of age are 18 and 30, but the upper limit is extended to 35 for entrants who have served 12 years in the Army or Navy, and to 45 for those who are receiving a pension. A great many of the candidates nominated have served as telegraph messengers.

London postmen number 6,196, and there are 44,959 in the provincial service. The wages paid in the Metropolitan area begin at 18s. and rise generally to 34s. a week, with stripe allowances varying from 1s. to 6s. weekly—according to length of approved service—and a boot allowance of 21s. a year. There are also a few senior and head positions beginning at 36s. and rising to 42s., 52s., or 60s. a week. In provincial offices the rates of payment vary widely, according to the area served and the duties performed, but are generally lower than in London, and the proportion of head positions is relatively less. At Edinburgh and Dublin, for example, the pay of postmen rises to a maximum of only 30s. instead of 34s. Further advantages of the London service, as we have seen, are the chances it affords to competent officers of securing nominations for sorterships and junior clerkships in the G.P.O. With regard alike to the London and the provincial service, it has long been felt that an ex-soldier or other candidate of mature age was at a great disadvantage in starting his service as a postman at the ordinary minimum salary to which a lad of 18 or 19 is entitled on joining. A recent and very wise provision of the Postmaster-General puts an end to this grievance, by enacting that every postman appointed to the permanent staff at or over the age of 25 shall at once receive not less than three increments above the initial wages of his class.

Continued

ELECTRICITY METERS

Power and Energy. The Wattmeter and the Integrating Wattmeter. Types of Meters. The Magnetic Brake and Starting Coil. Alternating Current Meters.

By Professor SILVANUS P. THOMPSON

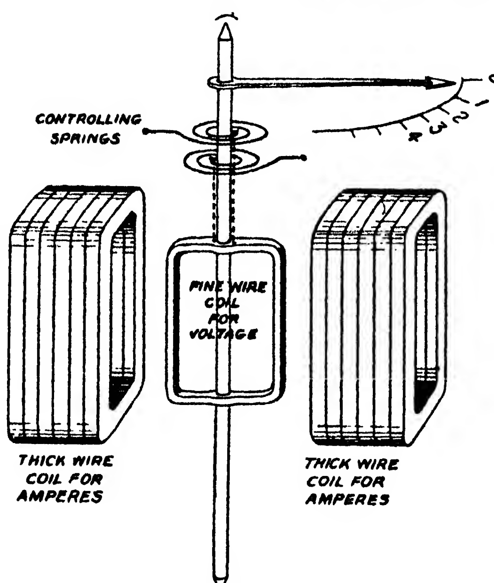
IN discussing the subject of electricity supply meters, the reader must have a clear conception of the various units used, and he is, therefore, recommended to reread the article beginning on page 288, where questions of current, pressure, power, and energy were dealt with.

Power and Energy. As might be supposed, the consumer is charged according to the total amount of energy which he takes from the mains. The energy might, of course, be measured in foot-pounds, but when we deal with energy in its electrical aspect, another unit, namely, the "Kilowatt hour," commonly called the Board of Trade Unit, is more handy. The *power*, at any instant, measured electrically in watts, is the product of the volts and the amperes at that instant. The *energy* is the product of the average power multiplied by the time during which the power has been taken. We can, therefore, differentiate the ideas of power and energy in one way by saying that the power may be continually *changing*—it may increase, or it may diminish from instant to instant, whereas the total energy consumed is always *growing* from instant to instant, and the quickness with which it grows depends upon the magnitude of the power. A power meter (in the electrical case called the *wattmeter*) gives its readings by means of a pointer which moves backwards and forwards over a scale, and does not necessarily leave any permanent record, but an energy meter has a dial and a counting train, and at any time shows a totalised record of what has taken place during the whole time preceding the moment of inspection.

Because of this an electrical energy meter is sometimes called an *integrating wattmeter*.

What the Electrical Energy Meter has to Measure. There are, therefore, three quantities which have to be taken into account in the energy meter—namely, the current, the voltage, and the time, and every variation in any or all of them must be faithfully accounted for in the final reading of the meter. To give an example of variations which may occur, we might have the meters of three consumers all reading 10 Board of Trade units, but A's demand may have been a uniform current of 10 amperes off 100-volt mains for 10 hours, B may have taken $2\frac{1}{2}$ amperes from a 200-volt circuit for 20 hours, and C may have been on the same circuit as A, and have taken 8 amperes for six hours, and, after a period of no demand at all, he may have completed his total demand of 10 units by taking 4 amperes for 13 hours.

In each case the meter has given us the product of the current, voltage, and the time, or the sum of the products of the current, voltage, and time, over a number of longer or shorter intervals.

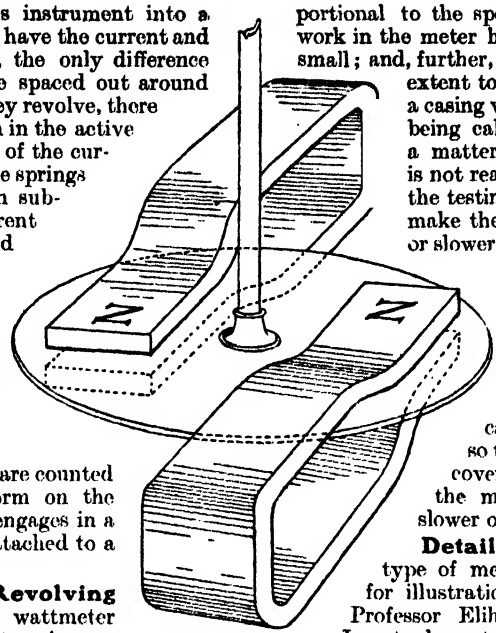


197. A WATTMETER

Wattmeter and Integrating Wattmeter. The product of the current and voltage is measured by the wattmeter [page 292], and we shall now see how the wattmeter construction is extended in order to take into account the third factor. Fig. 197 shows a typical construction for a wattmeter consisting of fixed thick wire coils which carry the current going to the lamps or the motors, and a thin wire coil which is connected across mains, and therefore carries a small current proportional to the volts, and which is mounted in bearings, and is free to turn against a couple of controlling springs, which also serve to convey the current to the fine wire coil. Such fine wire coils, or the *voltage coils*, as we may call them, will thus be alive all the time that the meter is connected, but the thick wire or current coils will carry current only during the time that lamps are on or motors running. It will be noticed that the coils have been placed at right angles to one another, so that, as explained on page 1590, there will be a drag on the coils, and the fine wire coil will turn round until the drag on it is counteracted by the force due to the winding up of the control springs. This drag will be proportional to the product of the currents in the two sets of coils [page 1591], and is, therefore, proportional to the power (watts) being absorbed in the circuit. Fig. 199 shows

the development of this instrument into a supply meter. Here we have the current and voltage coils as before, the only difference being that the latter are spaced out around a cylinder, so that, as they revolve, there are always some of them in the active region near the centre of the current coils. Instead of the springs a commutator has been substituted to bring the current into the rotating part, and the control now takes the form of fan blades, which are mounted upon the motor shaft. Again, the thin voltage coils carry current all the time, the thick coils only when a load is on the circuit. The revolutions of the armature are counted up by means of a worm on the rotating spindle which engages in a tooth wheel which is attached to a set of clockwork gears.

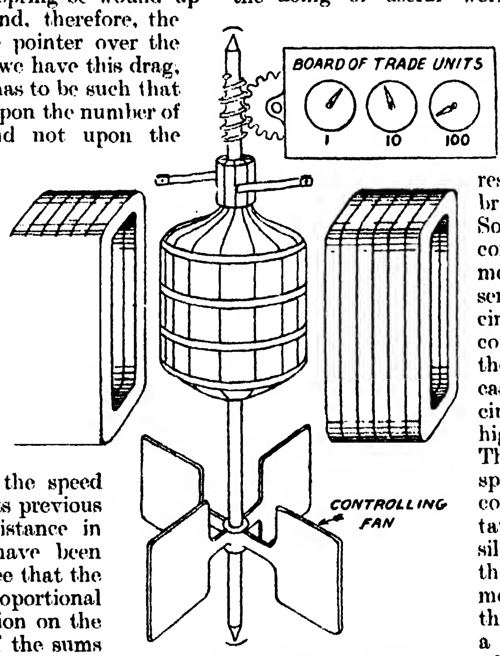
Control of the Revolving Element. In the wattmeter [197] the moving part, when a drag came on the coil, wound up a spring to such an extent that the drag on the moving coils was exactly counteracted by the tension from the wound-up spring. The greater the drag on the coils the more must the spring be wound up to counteract this drag, and, therefore, the greater the deflection of the pointer over the dial. In the supply meter we have this drag, but the control in this case has to be such that the resisting force depends upon the number of revolutions per minute and not upon the amount of deflection from an initial position. As will be seen, fan blades have been mounted upon the lower end of the shaft for this purpose. The resistance in the air to revolving blades is, up to moderate speeds, proportional to the speed at which they are revolving, so that in this meter, if the current be doubled and the drag or torque on the revolving part be doubled, the speed will gradually rise to double its previous value, for then the air resistance in the fan blades will also have been doubled. In this way we see that the speed of revolution will be proportional to the load, and the indication on the dial will be a true record of the sums of the products of the current, voltage, and time during the various intervals that the electricity has been used.



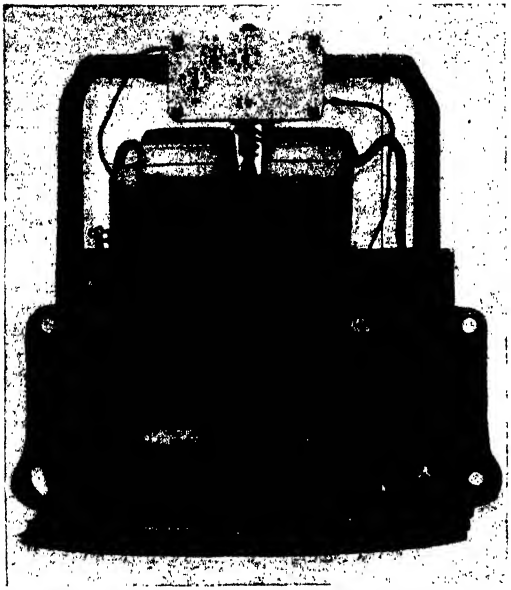
198. MAGNETIC BRAKE FOR METER

The Magnetic Brake. The fan is not the most convenient form of brake to use, as at high speeds its braking force is not proportional to the speed, so that the forces at work in the meter have in consequence to be small; and, further, its action depends upon the extent to which it is surrounded by a casing which necessitates the meter being calibrated with the case on, a matter of inconvenience; and it is not readily adjusted when, during the testing, it is found necessary to make the motor run a little faster or slower. The form of brake more often used is shown in 198, and depends for its action upon the generation of eddy-currents in a revolving copper disc by means of a permanent magnet. This magnet is capable of easy adjustment, so that by making the magnet cover more or less of the disc the meter is made to revolve slower or faster.

Details of the Meter. The type of meter which we have taken for illustration is that brought out by Professor Elihu Thomson, in America. In actual construction it appears as shown in 200. The revolving part or armature consists of eight coils equally spaced around the periphery, and connected to a small eight-part silver commutator. The current which passes through the armature is wasted so far as the doing of useful work is concerned, and should, therefore, be as small as possible. For this reason each coil on the armature has as many as 800 turns, and, taken altogether, the total resistance across the brushes is 640 ohms. Sometimes this is not considered sufficient and more resistance is inserted in the armature circuit in the shape of coils stowed away at the back of the meter case. This part of the circuit is therefore a high-resistance shunt. The brushes are of springy steel, but actual contact on the commutator is made by small silver plates soldered on the ends. As regards the mounting of the meter, the shaft terminates in a polished steel point, which rests on a jewel bearing. To preserve the point and jewel from damage due to jolting, the bearing is supported in guides by means of a spiral spring, so that a little up-and-down motion is obtained.



199. DIAGRAMMATIC ENERGY METER



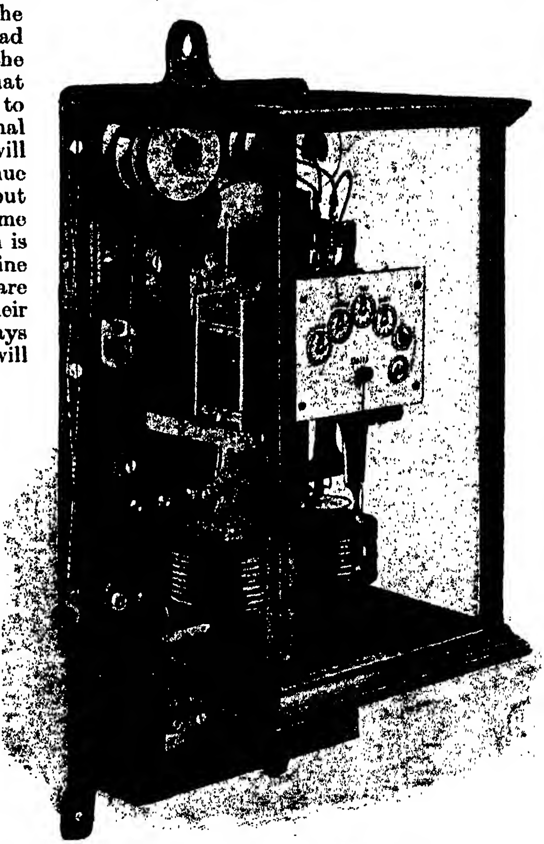
200. ELIHU THOMSON ELECTRICITY METER

The Starting Coil. In the meter, as so far described, a portion of the torque given by virtue of the current in the main coil has to be used to overcome the friction of the meter. The meter will consequently read slow by a percentage which increases as the load goes off, and it may even happen that the torque produced by the current taken to light one lamp may not exceed the frictional resistance of the meter, and so no turning will take place, and the consumer might continue to use the current for the single lamp without having to pay for it. In order to overcome the frictional resistance by a torque which is not derived from the main current, coils of fine wire are inserted inside the main coils, and are connected in series with the armature, their position being adjusted so that there is always a small torque being exerted which will counteract the frictional resistance.

Types of Electricity Meters. The Thomson meter is not the only type of meter in use. It is one of a type known as *motor* meters, the other principal types being *clock meters*, *integrating meters*, and *electrolytic meters*. Each type, of course, takes a number of different forms, but it will suffice for our purpose to indicate briefly the principles of working.

Clock Meters. This type was invented by Ayrton and Perry. In Aron's form of this meter there are two pendulums of equal length, and driven by a clockwork which may be wound up by hand or electrically. If the two pendulums be of equal length, they will swing at equal rates, but on the bob of one is wound a coil of fine wire which will carry a current proportional to the voltage, and underneath the pendulum is wound a coil of thick wire, which will carry the main current. Now, the currents in these two coils will react upon one another, and, according to whether they are connected up to help or oppose one another, the pendulum will vibrate at a quicker or slower rate than the other. By means of a differential gear the difference in movement between the two pendulums can be registered. It is found, however, that the registrations are much more accurate if both pendulums are fitted with coils so that the one pendulum is retarded and the other is hastened; and this is the usual construction adopted to-day, as shown in 201.

Integrating Meters. These meters work intermittently. They are essentially wattmeters, which are switched on once every minute or every half minute; the forward swing of the moving part being each time communicated to the counting mechanism by means of a ratchet and pawl. They are, of course, not absolutely accurate; but, under ordinary circumstances, if the measurements are taken with sufficient frequency, their indications are reliable. To illustrate their defect, let us consider the case of a night sign, which goes through its cycle of operations once a minute, and, during the minute, it is on for 55 seconds, and off for five seconds. If the meter be

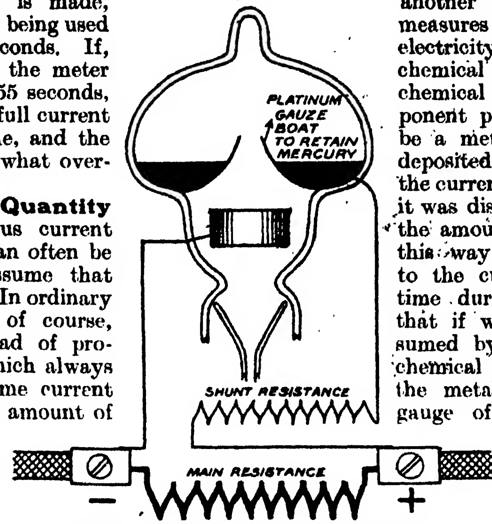


201. ARON'S PENDULUM METER

actuated once a minute, and if the moment of working happen to come in one of the five seconds during which the lights are off, there is no registration, and no charge is made, however much current is being used during the other 55 seconds. If, however, the action of the meter takes place during that 55 seconds, it will register as if the full current had been on all the time, and the consumer would be somewhat overcharged.

Ampere-hour, or Quantity Meters. In continuous current meters a modification can often be introduced if we can assume that the voltage is constant. In ordinary house lighting this is, of course, the case, and so, instead of providing fine wire coils which always are going to carry the same current and produce the same amount of magnetism, we may use a permanent magnet, the armature now carrying the main current, or a portion of it. As a matter of fact, the whole current is generally too large to be sent through a delicately constructed commutator, and the wires necessary to carry it would be too thick and clumsy, so that a greater portion of the current is passed through an outside resistance, and only a small part flows into the armature. Fig. 203 shows a meter of this type made by the Electrical Company. The braking action is furnished by the aluminium cylinder, on which the armature coils are mounted, revolving with them between the poles of the permanent magnet.

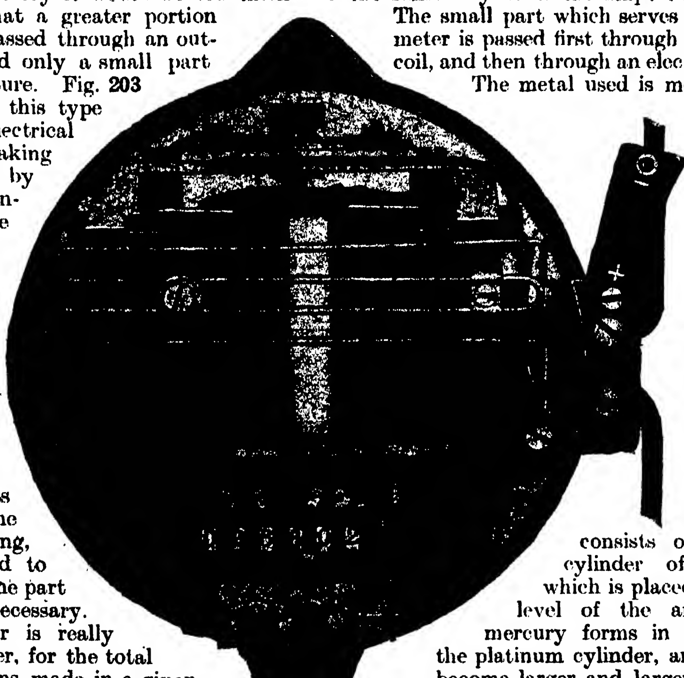
The resistance wire, which carries a larger portion of the current, is seen in the front, and for effecting adjustments during the testing the wire is made too long, and a clamp is used to bridge across from one part to another as necessary. This class of meter is really an *ampere-hour* meter, for the total number of revolutions made in a given time is a register of the total amount of current, or, in other words, the sum of the currents which have been flowing from second to second, but the dial is numbered in kilowatt-hours, because, as the voltage is constant, the ampere-hours are proportional to the volt-ampere hours—that is, to the kilowatt-hours or Board of Trade units [page 292].



202. WRIGHT ELECTROLYTIC METER

The Electrolytic Meter. This is another type of meter which measures ampere-hours. When electricity is passed through a chemical solution [page 288], the chemical is split up into its component parts, and, if one of these be a metal, we have that metal deposited upon the plate by which the current leaves the liquid. Now, it was discovered by Faraday that the amount of metal deposited in this way is exactly proportional to the current flowing and to the time during which it flowed, so that if we send the current consumed by a customer through a chemical solution, the weight of the metal deposited is an exact gauge of the ampere hours he has taken, and if the voltage be constant, of the Board of Trade units also.

A typical meter of this type is the "Wright," shown diagrammatically in 202. Most of the current passes through a bye-pass resistance in the same way as in the ampere-hour meter. The small part which serves to work the meter is passed first through a resistance coil, and then through an electrolytic cell. The metal used is mercury, and the anode consisting of this metal is held in a specially shaped receptacle of the cell. The electrolyte is a concentrated solution of mercurous nitrate, and the kathode on which the mercury is deposited consists of a hollow cylinder of platinum, which is placed below the level of the anode. The mercury forms in globules on the platinum cylinder, and as these become larger and larger they drop off into a funnel, and so into a narrow tube. The height to which the mercury stands in this tube is a record of the total amount of electricity passing through the meter.

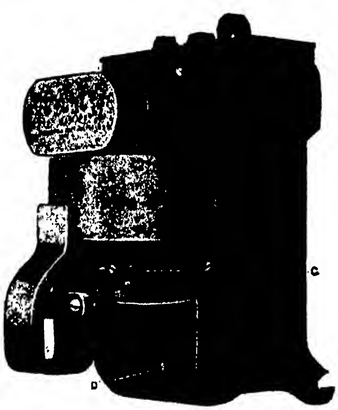

203. AMPERE-HOUR METER (The Electrical Co.)

Alternating Current Meters. Many types of meter, including the Thomson and Aron

meter, already described, can be used for both alternating and continuous current, while others, such as the ampere-hour meters, already mentioned, are suitable for continuous current only. A type of meter which can be used on alternating current circuits only is the "induction" meter, which, as its name would indicate, works on the principle of the rotating field, as used in the induction motor [page 1909]. A typical construction of this type of meter is shown in **204**. At the back of the instrument are mounted the main and the shunt coils, which together produce the rotating flux, which, acting on a copper cylinder shown mounted in place in **205**, causes it to rotate in the same manner as the short circuited rotor of an induction motor. The value of the inducing flux depends, of course, upon the current in the coils—that is, upon the load on the mains—and a brake magnet being used upon another part of the cylinder, the rotation is proportional to the power taken by the customer.

204. ALTERNATING CURRENT METER, DISMOUNTED

Meters and Tariffs. By the Electric Lighting Acts no supply company is permitted to charge the consumer more than 8d. per Board of Trade unit; but, as a matter of fact, the charges everywhere are now much below this figure. Very seldom is the price in England more than 4d. per unit. In fact, by the economies effected in the cost of generation, by the use of better engines and boilers, and larger sets of machinery, the adoption of condensing plant, the design of more efficient dynamos, and other improvements, the cost per unit generated has come down to about 2d. per unit in the smaller stations, and to less than 1d. per unit in the very large stations. But to this must be added the cost of distribution, and interest on capital expended, together with allowances for maintenance and depreciation, and other standing charges. Hence one finds that small customers are still charged about 4d. per unit for the current supplied for lighting their houses.



205. ALTERNATING CURRENT METER, COMPLETE

But it is now also usual to find that the same companies which charge, say, 4d. per unit for electric lighting are ready to supply current for motors or for heating at a much lower tariff—for example, at 2d. or 1½d. per unit. This is puzzling to those who do not understand the circumstances which govern the economic production of electric supply. It depends, in fact, on the *load-factor*.

Load-factor and Meter Rates. Consider an ordinary residential district supplied with electricity for lighting. There is a small demand for current early in the morning, particularly in winter. All through the hours of daylight there is, however, very little demand for lighting, except on dark or foggy days, and it is only as afternoon darkens that the demand for current again sets in. At sunset everybody turns on the lights, with the result that there is a huge demand for current, which comes to a maximum about six or seven o'clock, after which the demand gradually goes down until ten or twelve at night. Now it is evident that at the supply station there must be engines, boilers, and dynamos at work in sufficient quantity to meet the maximum demand, and as this maximum demand lasts less than two hours on the average, it is clear that a great part of the plant, particularly in the summer months, must lie idle most of the day. Clearly, if expensive machinery lie idle the greater part of the time, the charges made must be greater than if it were in continuous full use. The name *load-factor* is given to the ratio of the average time of use to the total possible time of use. If the total output of a station during a day were equal to only two hours of continuous work out of the 24 hours, the load-factor would be $\frac{1}{12}$, or 8⅓ per cent. Now, if current be supplied for heating or motive power to a factory throughout a working day of eight hours, the load-factor of that supply may be as high as 33 per cent. and obviously the rate that is charged may be much lower. For tramways running all day, a rate of 1½d. per unit is very profitable.

Maximum Demand Meters. As a consequence of these considerations many supply companies charge their consumers by a scale based on the total amount consumed during a quarter of a year as compared with the maximum demand of that consumer. A consumer who takes a very little total energy but who draws a lot of current for a very short time, is not at all profitable. So, therefore, supply companies fix in the consumer's house not only the ordinary meter, but also an instrument called a *maximum demand meter*, which registers the largest number of amperes which he took at any one time.

Continued

SOUTH-WEST ASIA & INDIA

Arabia. Persia. Afghanistan. India: its Physical Features, Climate, Vegetation, and Mineral Wealth. Basins of the Indus and Ganges

Group 13
GEOGRAPHY
20

Continued from page 2719

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

ARABIA

The tableland of Arabia, averaging 3,500 ft. in height, rises to 10,000 ft. in the south-east, and is only 1,000 ft. lower in the peninsula of Sinai in the north-west. It is one of the driest regions in the world, with cold winters in the higher parts and hot summers. Much of it is sandy or stony desert, but those valleys which have running streams are very fertile. The date is widely grown, and coffee, gums, and spices are produced in the fertile parts of Southern Arabia. Where pasture is good the keeping of animals is very important, and the horse and camel are closely bound up with the life of the Arab, who is still a wanderer, dwelling in tents, which are made from the wool and hair of his flocks by the women of his family. The ports are Jedda and Hodeida, on the Red Sea, and Oman on the Persian Gulf. Pilgrimages are made to Mecca and Medina, which are to Mohammedans what Bethlehem and Jerusalem are to Christians. Aden, in the extreme south-west, amid burnt-up surroundings, is British. Much of Arabia is ruled by independent native chieftains.

PERSIA

This country (628,000 sq. miles) is a plateau 6,000 to 7,000 ft. high, sinking steeply to the Caspian in the north, and to the Persian Gulf in the south, with narrow coastal plains along these seas. The northern margin of the plateau is formed by the Elburz Mountains, with Demavend (18,000 ft.) and other lofty peaks. In the extreme north-west, on the Armenian frontier, is Ararat, almost as high. Most of the surface of Persia is treeless, and there are large areas of salt desert. The rivers are short, and few reach the sea. The climate is extreme and the rainfall scanty. Snow falls on the western mountains in winter, and, melting in spring, fills the dry river beds, supplying water, which is distributed by underground canals to prevent loss by evaporation, for the purpose of irrigating the lands round the villages during the hot, rainless summer. These villages make little islands of verdure in the brown, parched landscape. In their orchards ripen the vine, olive, peach, apricot, nectarine, pomegranate, fig, almond, and other fruits equally delicious. In the valleys of the north-west wheat grows ripe up to 9,000 ft., and rice is much cultivated around the Caspian. Cotton is also grown. The staple products, however, are wool and hair from the vast numbers of sheep, goats, and camels pastured on the plateau. Persian rugs and carpets are famous all over the world.

Persian Towns. The towns of Persia are often separated from each other by many days' journey over mountain and desert. As might be expected in such a country, the roads are few and bad. From Resht, the Caspian port, a route climbs the wet, forested northern slopes of the Elburz to the dry, arid southern slopes, at the base of which, on the plateau, is Teheran, the capital. Another important northern town is Tabriz, in the region of salt lakes, south of the Aras. Kermanshah, further south, trades with the Euphrates towns. On the Persian Gulf are Bushire, Bandar Abbas, and other ports. Ispahan, Yezd, Kerman, and Shiraz, with its rose-gardens, are inland towns. Near the Russian frontier is Meshed, which could easily be connected by rail with the Transcaspian line. [See 112.]

112. PERSIA AND AFGHANISTAN

AFGHANISTAN

Afghanistan is a higher, bleaker land than Persia, rising towards the lofty Pamir plateau, the Hindu Kush, and the Suleiman Mountains. The climate is extreme. In summer, the valleys are intensely hot, and two harvests can be reaped—one of wheat, barley and lentils, in spring, and one in autumn of rice, cereals, fruits and tobacco. The roads are of the roughest description, and the camel the only pack animal. The people are hardy, fierce mountaineers, whose main occupation is the keeping of animals on the pastures of their steep mountain valleys, down which rush the torrents fed by the snows of the mighty mountains above. Those flowing north find their way to the Oxus, while others flow south to the Indus. Of these, the most important is the Kabul River. The route from India after traversing the Khaibar Pass follows this river to Kabul, the capital

of Afghanistan. The Helmund flows west by Kandahar to the more arid portion of the country, losing itself at last in a lake of considerable size. Further north is the Hari Rud, with Herat, to which a branch of the Transcaspian line is projected. [See 112.]

INDIA

From whatever point of view we regard our Indian Empire, it presents great diversity. Its surface varies in elevation from the summit of the Himalayas to the sea level, and shows every type of fertility, from tropical jungle to arid desert. Out of rather more than 1,500,000 sq. miles, 665,000 sq. miles, or roughly two-fifths, are governed by native rulers, who stand in varying relations to the central power. There is no community of either race or religion, and all types of civilisation are represented, from the highly cultured Hindus to the semi-savage tribes of the jungle.

Physical Features of India. Enough has already been said of the great mountain ranges which wall in India on the north. Upon their flanks lie the mountain states—British Baluchistan, the North-West Frontier province, Kashmir, the wholly independent states of Nepal and Bhutan, and Assam.

At the base of this mountain wall extend the vast alluvial plains of the Indus and Ganges, built up in the slow course of ages out of the silt brought down by these mighty rivers and their tributaries. Five great tributaries of the Indus, the Jhelum, Chenab, Ravi, Beas and Sutlej water the Punjab, or Land of the Five Rivers, and unite to cross Sind to the Arabian Sea. The innumerable tributaries of the Ganges cross the United Provinces and Bengal, receiving in the deltaic portion the Brahmaputra from Tibet and Assam. The desert of Rajputana, under native rulers, lies between the Indus and the Ganges. The right bank tributaries of the Ganges flow in parallel valleys from the northern margin of the Deccan plateau, which occupies the centre of peninsular India. In the west it rises steeply from the sea. The high western margin, which, seen from below, appears as a mountain range, is called the Western Ghats, or Stairs. In the east it sinks gradually to a broad coastal plain, which extends along the whole length of the eastern, or Coromandel coast. Here, the much less well defined eastern margin forms the Eastern Ghats. The northern margin is well defined, and forms the Aravalli Mountains, south-east of which lie the Central Indian native states. South of the Vindhya Mountains is the deep gorge of the Narbada, which flows west across the Deccan plateau and crosses the lowlands round the Gulf of Cambay to the Arabian Sea. Parallel to it, separated by the Satpura Highlands, is the Tapti. All the other rivers of the Deccan flow east, the Mahanadi, the Godavari, the Kistna or Krishna, Canvery, and others. The plateau narrows with the peninsula, the southern margin forming the Nilghiri Hills. South of these is a remarkable depression, the Palghat Gap, beyond which rise the Anamalai Hills of the extreme south. The most important political divisions of the Deccan are the Central Provinces and Berar, between the Narbada and the Godavari, the large native state of Haiderabad, between the Godavari and Kistna, while further south is the native state of Mysore. Bombay forms the western, and Madras the eastern maritime province. [See 113.]

Ceylon and Burma. South of India, and not administratively included with it, is Ceylon (25,000 sq. miles). It is an island, mountainous in the centre and south, separated from the mainland by Palk Strait.

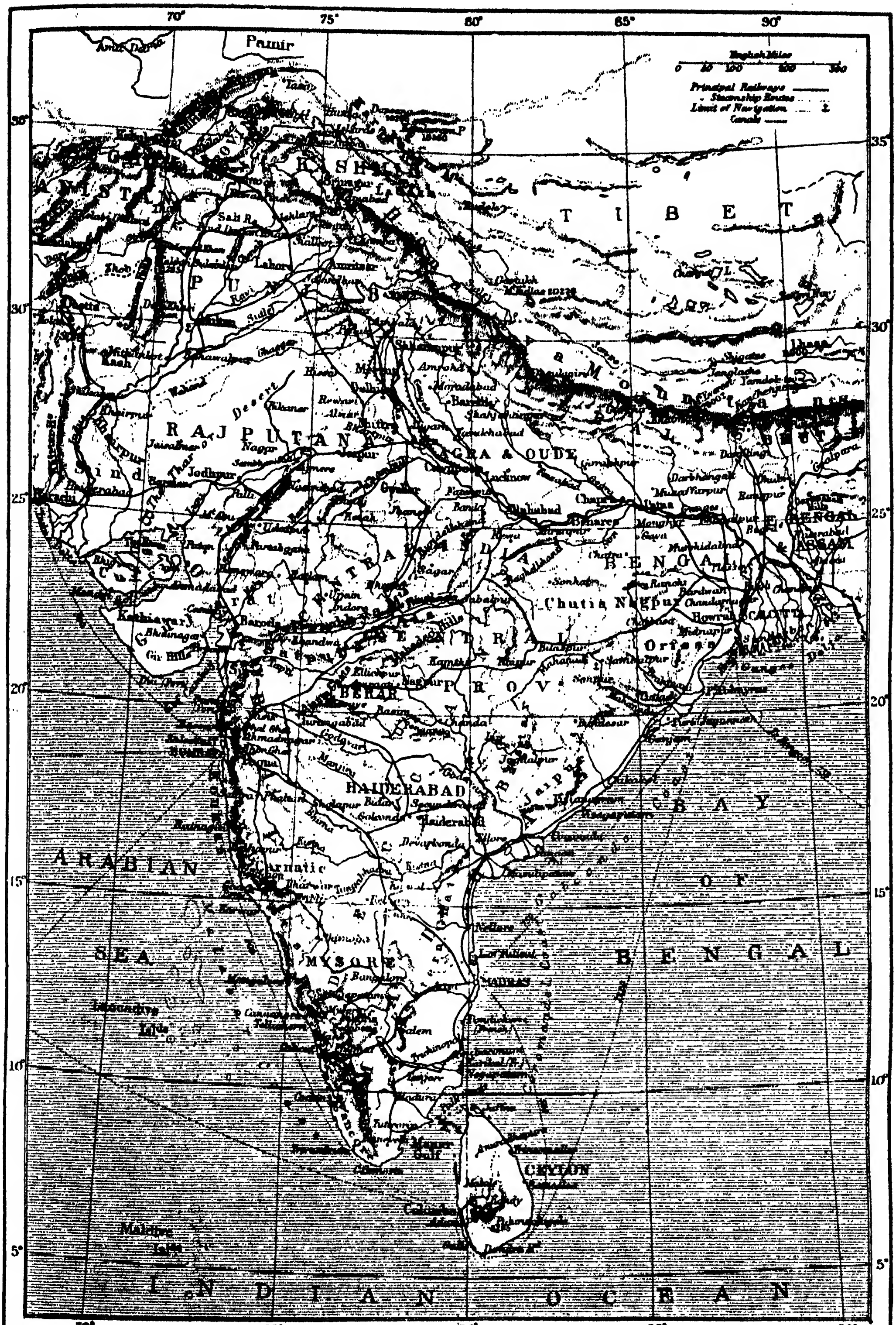
Burma lies entirely east of peninsular India, but is politically part of that country. It occupies most of the basin of the Irawadi. Upper Burma consists of forested and little-known mountain ranges running north and south, with tributaries of the Irawadi flowing between them in parallel valleys. Lower Burma consists of the fertile lowlands of the delta.

Indian Climate. The climate of India, like its surface, is very varied. On the coasts the temperature is high throughout the year, with less variation than in the interior. The highest temperatures in summer are recorded in Sind, the Punjab, and Baluchistan. These regions lie more or less outside the influence of the rainy south-west monsoon, which lowers the summer temperature. Rajputana and Sind are almost rainless, forming an area of true desert.

Rainfall. The coming of the south-west monsoon, the most dramatic feature of Indian climate, has already been described. It strikes with great violence on the Western Ghats, which have a rainfall of over 100 in., while the Western Deccan in their lee has less than 20 in. The rainfall is also extremely heavy in Burma, Assam, and the Ganges Valley, the highest rainfall in the world being experienced at a place in the Khasi Hills, which has the enormous rainfall of 40 ft. per annum. Just before the monsoon bursts the Deccan is the hottest part of India, but during the monsoon months—June to October—the highest temperature occurs in Sind and the arid highlands to the west, where a shade temperature considerably above 100° F. may last for many consecutive days. The climate of all this region is very extreme, for the arid soil, unprotected by vegetation, loses its heat rapidly by radiation during the night, and the winters are cool. In the Punjab the hot summers are compensated for by several months of bracing cool winter weather.

In autumn the south-west monsoon begins to recede, its place being taken by the north-east trades, now moving south with the sun, and often called the north-east monsoon. It prevails from November to February. The first two months, called the period of the retreating south-west monsoon, is the wet season in South-east India and the eastern part of Ceylon, but the rainfall thus caused is much less than that brought by the full south-west monsoon.

Irrigation. The seasonal character of the Indian rainfall makes it a matter of prime importance to store water for use in the dry season. An ancient Indian method was



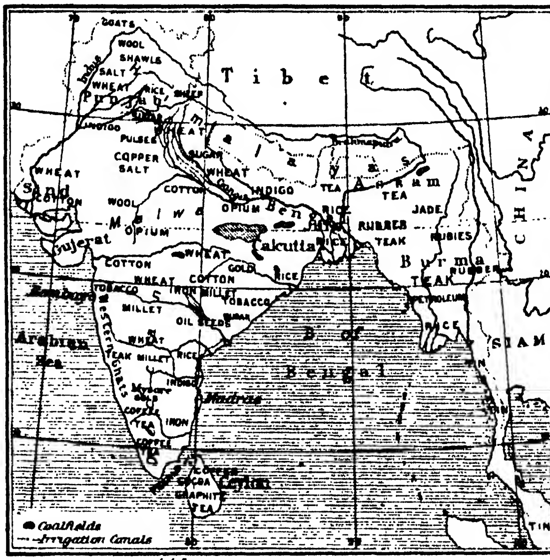
113. MAP OF INDIA

to construct tanks, subterranean reservoirs and artificial lakes. Innumerable wells were sunk to the water-bearing strata. Canals were also made to carry off the flood waters of the rivers in spring, when they are enormously swollen by the melting of the mountain snows. This surplus water was then distributed by smaller irrigation canals. Under British rule great engineering works have made not merely the flood but the perennial waters of the rivers available for irrigation. Wherever possible the country is covered with a network of canals, the regulation of which is one of the greatest services rendered by Britain to India. All these precautions, however, do not prevent local famines, whenever the south-west monsoon is scanty.

Vegetation. The vegetation of India is luxuriant or the reverse according to the rainfall. Everywhere it strikes unfamiliarly on the European eye. Palms are abundant, and are of many species. The coco-nut palm does best near the sea. Many of the tropical palms of Southern India and Ceylon cannot stand the cold winters of Northern India, but the hardy date palm thrives even in the dry, extreme climate of Sind. At the base of the Himalayas is the fetid jungle area known as the *terai*, deadly to Europeans. Above are magnificent forests of sal and deodar—a cypress—with tea plantations in the clearings. Above these are woods of brilliantly coloured rhododendrons, making a wonderful sight. The hotter, wetter forests of Burma supply teak, one of the hardest timbers in the world. It is also found in the Western Ghats and other hot, wet parts of the peninsula. Valuable forest trees are ebony, satinwood, sandalwood, the gum-arabic tree, and many others. The great banyan is grown as a shade tree. Of the many fruit trees unfamiliar to us, the pipal, or sacred fig, the mango, the tamarind, the guava, etc., may be mentioned. The bamboo, a gigantic grass, is very valuable, especially to the forest peoples, who can make from it almost anything that human needs require.

The cultivated plants include many cereals, the variety depending on the climate. Large quantities of wheat are grown in Northern India and in the Northern Deccan as a winter crop in the cool months. Rice, the typical cereal of warm, damp countries, is universally grown in the Ganges and Brahmaputra delta, in Burma, and in most of the swampy coastal plains of the peninsula. A universal crop is millet, which can be grown in poor soils. Other very common crops are pulses and oil seeds (sesame, linseed, rape, castor-oil, mustard). Sugar-cane, indigo, and tobacco are widely grown. Of fibre plants cotton and jute are important. The latter is confined to Bengal, but cotton is grown wherever there is a moderate rainfall. The great cotton-growing region is the Deccan, with its rich black, moisture-holding soil, and Gujerat. Tea in the Himalayas, and in the Assam hills, has already been mentioned. Coffee is cultivated on the lee slopes of the Western Ghats, in Southern India. [See **114**.]

Minerals. The mineral wealth of India is considerable. Coal is worked in Bengal, Assam, Central India, Haiderabad, and Baluchistan. Southern India, though poor in coal, is rich in other minerals. Iron is widely distributed, but unfortunately seldom occurs near coal and limestone; gold is abundant in Mysore; tin and petroleum are found in Burma; Upper Burma has fine rubies and Ceylon precious stones. Golconda, in Haiderabad, was proverbially famous for cutting and polishing diamonds, not for producing them.



114. PRODUCTS OF INDIA

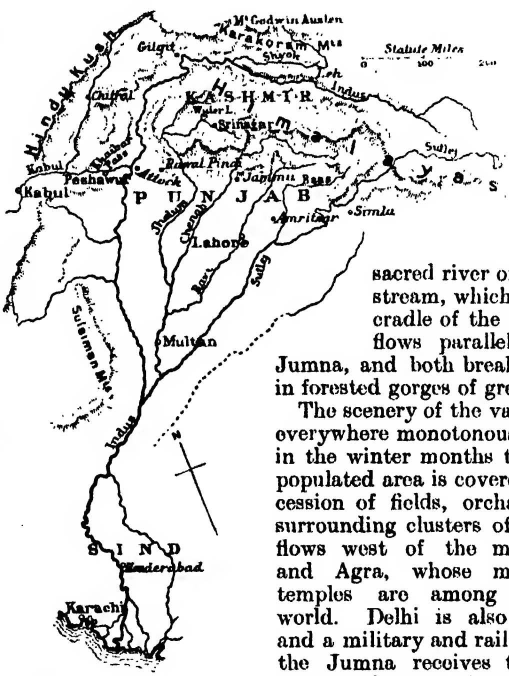
The Occupations of India. India is primarily an agricultural country. A pastoral belt stretches across Northern India from Cutch to Kashmir, and everywhere flocks and herds are kept in the mountain pastures.

The manufactures of India—fine textiles and metal work—have always been famous in Europe. These, like the more common trades of the smith, potter, etc., are handed on from father to son, and skill and taste doubtless become hereditary. In recent years machinery and the factory system have been introduced, to the rapid deterioration of the manufactures affected: In Bengal jute factories make gunny-bags for packing exports. Cotton mills are numerous near the cotton growing regions in Bombay.

The Indus, Punjab, and Sind. The Indus and its great tributary the Sutlej rise between the inner and outer Himalayas in Tibet. Both first flow north-west, parallel to the axis of the mountains, but the Sutlej soon breaks south through the Himalayas in magnificent forested gorges, to the plains of the Punjab. The Indus flows in wild and gloomy defiles through the bleak scenery of Eastern

Kashmir, passes Leh, the starting point of caravans across the mountains to all parts of Central Asia, and after receiving the Shyok from the Karakorams, bends to the south near the base of Mount Godwin Austen, the second summit of Asia. It now flows between the mountains of Gilgit and Chitral on the right, across which lie difficult routes to the Pamirs and Russian and Chinese Turkestan, and the mountains of Western Kashmir on the left. Among the latter rise its tributaries the Jhelum, whose level upper valley forms the far-famed Vale of Kashmir, with Srinagar, the summer capital near Wuler Lake, and the Chenab. Both descend steeply to the Punjab plains, Jammu, the capital of Kashmir, being built on a tributary of the Chenab, near where it leaves the mountains. The main stream of the Indus emerges into the high Peshawur plain, where it breaks up into a network of channels, which join up again to form one main stream near Attock, where the Kabul river comes down from Afghanistan. Here the Indus is crossed at the line from Lahore in the Punjab to Peshawur, an important military post, commanding the Khaibar route to the capital of Afghanistan by the Kabul river. Below Attock, the river, now descending rapidly in a narrow gorge, is a wild and dangerous torrent, only to be crossed by the most experienced native boatmen. At last it reaches the plains of the Western Punjab, less fertile than those of the Eastern Punjab, which are watered by the Jhelum and Chenab from Kashmir, and by the Ravi, Beas, and Sutlej from the Himalayas, all dividing into many channels—dry in early summer, but later filled by raging torrents, fed by the melting Himalayan snows. The whole region consists of wide, flat plains, bare and brown or golden with wheat, according to the season of the year. The slopes of the Himalayas, on which is Simla, the summer capital of India, add timber and tea to the resources of the Punjab.

The chief cities are Lahore, the capital of the Punjab, near the Ravi, with many manufactures and many radiating lines of railway; Delhi, in the Ganges basin; Amritsar, the centre of Sikh faith and influence, manufacturing Kashmir shawls; and Rawalpindi, a military station in the extreme north, between the Jhelum and Indus. The other Punjab rivers unite with the Sutlej some distance below Multan, an important town on the line between the wheat districts of the Punjab and Karachi, the port of the Indus. The united stream, known as the Punjnad, soon after unites with the main stream, and flows across the arid region of Sind, past Haiderabad, to its great delta. Karachi, the port, ships the wheat and other produce of the Punjab. [See **115**.]



115. BASIN OF THE INDUS

Rajputana. East of the Indus lies Rajputana, the northern part of which is a sandy desert, where camels and goats are kept wherever the scanty herbage is sufficient. Beyond the Aravalli Hills, the north-west edge of the Deccan plateau, the country improves, and has long stretches of hills and woodland, several rivers, and fertile vales and plains. The chief city of Rajputana, which is divided among native rulers, is Ajmere, at the northern end of the Aravallis.

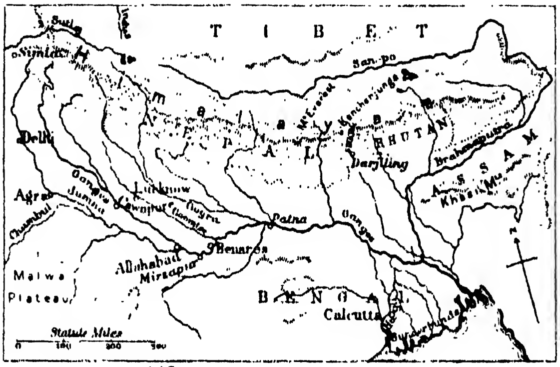
Ganges Basin and United Provinces. The waters of the Himalayas, east of Kashmir, are carried to the Indian Ocean by the Ganges, the sacred river of the Hindus. The main stream, which has risen in the Tibetan cradle of the great Himalayan rivers, flows parallel to its tributary, the Jumna, and both break through the Himalayas in forested gorges of great beauty.

The scenery of the vast plains of the Ganges is everywhere monotonous. During the rains and in the winter months the whole of this densely populated area is covered by "an unbroken succession of fields, orchards, and mango groves surrounding clusters of villages." The Jumna flows west of the main stream past Delhi and Agra, whose magnificent palaces and temples are among the wonders of the world. Delhi is also a manufacturing city, and a military and railway centre. Below Agra the Jumna receives the Chambul, from the Malwa plateau of the Deccan, a centre of opium and cotton culture. Allahabad is built where the Jumna unites with the Ganges, which has flowed past Cawnpore; the latter has leather and textile manufactures. The great river passes Mirzapur, the Birmingham of India, and Benares, the holy city of the Hindus, whose wonderful metal industries and fine textiles have long been world famous. Lucknow, on the Goomtee, is also a manufacturing centre, whose native cloth of gold tissues are as famous as those of Benares. Below the confluence of the Gogra is Patna, in Bengal. All this region is fertile and carefully cultivated. [See **116**.]

The Himalayan rivers never run dry, as do those which flow from the Deccan to the right bank of the Ganges. Tea is grown on the lower slopes of the Himalayas, whose forests supply sal and other valuable timber. The

opium poppy and all Indian crops are grown, with wheat as the chief winter crop. Rice is grown in the swamp lands during the rains. It becomes the staple crop in Bengal, the basin of the lower Ganges. The southern margin of the delta forms the Sunderbunds, a region of swampy forest or jungle, everywhere intersected by water.

Bengal. Calcutta, the capital of the Bengal Presidency and the seat of government for our Indian Empire, is built on the Hugli distributary of the Ganges. During the intolerable heat of summer the viceregal court moves to Simla, in the Punjab Himalayas. The chief hill station of Bengal is Darjiling, in the Sikkim Himalayas, commanding fine views of the giant peaks of Sikkim and Nepal, the monarch of which is Kanchenjunga. From points not far distant a glimpse of Mount Everest is caught. Both Nepal and Bhutan are independent states, occupied by hardy hill tribes who drive their flocks to the high summer pastures and descend to the valleys in winter.



116. BASIN OF THE GANGES

The southern margin of the Ganges basin is the wild hill land of Chota Nagpur, with vast forests and large deposits of coal. The northern part is being cleared and cultivated, and the people live in settled villages or work in the mines. The southern part is still the home of wandering, half civilised aboriginal tribes, who live on the produce of the forest.

Bombay. It is difficult to state briefly the limits of the western maritime province, which includes the lower Indus basin and extends along the coast to the frontiers of Madras. Besides the alluvial plains of the coast, it takes in the western escarpment of the Deccan plateau and part of the plateau itself. Sind, in the Indus basin, has already been described. To the south is Cutch, almost cut off from the mainland by the Rann of Cutch, a broad belt of salt marshes in summer and salt desert in winter. In Gujerat and all round the Gulf of Cambay cotton is grown, with wheat as a winter crop. The hot, moist coastal plain and Western Ghats are covered with rich tropical vegetation, and on the plateau above enormous quantities of cotton are grown in the fertile black soil. Bombay, the capital of the presidency and rapidly becoming the first city of India, is the great market from which cotton and all Indian produce, brought down to it by many converging railways, is shipped through the Suez Canal to Europe. It is built on many islands, now practically made a peninsula by the silting up and bridging of the straits between. Its fine harbour, advantageously situated for the Suez Canal trade, its growing cotton manufactures, and its excellent railway communications ensure its permanent prosperity. On the Ghats above is Poona, the Simla of the presidency. Ahmedabad, near the Gulf of Cambay, Surat, on the Tapti, and many other towns manufacture cotton, either by hand or machine power.

Central India. Over 80 native states, the largest being Gwalior and Indore, lie around the northern margin of the Deccan, where the great escarpment of the Vindhya mountains faces the Aravalli hills. All are hilly or undulating. Though drier than the Ganges basin, the rainfall is sufficient for successful cultivation. Cotton and opium are grown in the hilly Malwa plateau in Indore. The summer crops are very varied, and wheat is grown as a winter crop. The chief river is the Narbada, which rises in the eastern part of the plateau and flows past Jabalpur, and through its famous gorges of white marble westwards into Bombay.

Berar, under British control, lies in the upper Tapti basin, the lower course of which is in Bombay. It is a hilly region with valuable forests and large areas of black cotton soil. The chief cotton market is Amraoti.

The Central Provinces. These include the highest part of the Deccan plateau, with the sources of the rivers flowing both east and west. The surface consists of rugged hills and plateaux, enclosing fertile and well-cultivated plains, with much black cotton soil. The rainfall is fair, and the summers less hot than in many other parts of India, while the winters are mild. Much wheat and pulse are grown in the Narbada valley in winter, and in the rich agricultural district round Raipur, drained by the Mahanadi, replaced by rice in the rainy season. The forest produce is rich and varied. Coal is abundant. The chief towns are Nagpur, in a plain east of the Satpuras, Jabalpur, on the Narbada, and Raipur in the east.

Continued

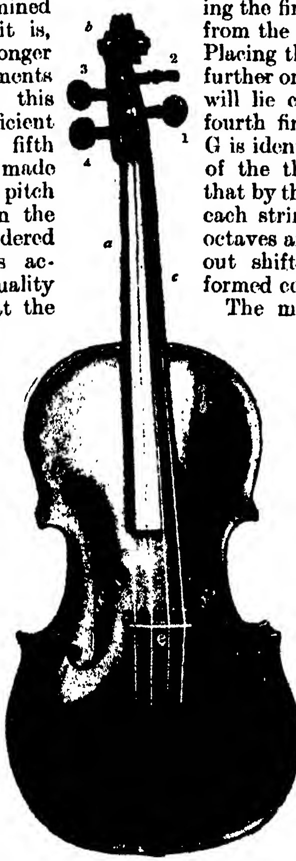
THE VIOLA

Parts of the Instrument. The Bow. Tuning. Expression. First, Second and Third Positions. Exercises

By PAUL CORDER

THE viola, called sometimes the tenor, is a member of the violin family, to which instrument, although larger, it bears a very close resemblance. So great, indeed, is this similarity that we not infrequently find a viola player who began his musical career as a violinist ; and the study of the violin will be found beneficial when we take up the larger instrument. The aspiring viola player is therefore recommended to study the course on the VIOLIN [see page 2121].

The size of the viola is determined by no hard and fast rule, but it is, roughly speaking, about 3 in. longer than the violin, its other measurements being proportionately larger. Yet this increase of size is acoustically insufficient for the viola's deeper compass (a fifth below the violin), but if it were made of the full size demanded by its pitch it would be impossible to hold it in the usual way. It is generally considered that this relatively small size is accountable for the viola's peculiar quality of tone, and there is no doubt that the larger the instrument, the fuller and more resonant is its sound. As may be supposed, the tone of the viola bears a certain resemblance to that of the violin, but it has a distinguishing quality of its own—in the higher positions a nasal and penetrating *timbre*, while the middle and lower registers are apt to sound weak in any save skilful hands.



1. THE INSTRUMENT

The names applied to the various parts of the instrument will be understood on reference to 1.

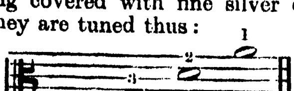
The *body* consists of the *belly*—*i.e.*, the front—of the instrument, the *ribs* (forming the sides), and the *back*.

a is the *neck*, terminating in the peg-box.

b is the *scroll*, at the end, merely ornamental; attached to the neck is the fingerboard, *c*.

d is the *tailpiece*, to which the ends of the strings are attached, afterwards passing over the *bridge*, *e*.

The *f* holes, or sound holes, are marked *f*. The four strings are made of gut, the two lower ones being covered with fine silver or copper wire. They are tuned thus:



It should here be mentioned that music for the viola is written, for the most part, in the alto clef. [See MUSICAL THEORY.]

These four notes sounded by the strings are termed *open notes*. The other sounds necessary for the completion of the scale are obtained by firmly pressing the string on to the fingerboard with the fingers of the left hand, thus in effect temporarily shortening the string, the exact pitch being determined by the position of the finger on the fingerboard. Thus, on the C string, by pressing the first finger on the string about 1½ in. from the end, the note D will be produced. Placing the second finger the same distance further on will give E. F, being a semitone, will lie closer to the E, while G with the fourth finger is again a whole tone. This G is identical in pitch with the open note of the third string. It will now be seen that by the successive use of three fingers on each string a complete scale of C for two octaves and a third can be produced without shifting the hand. The notes thus formed comprise the first position.

The manner of holding the viola is so similar to that of holding the violin that the student is referred to the instructions given for that instrument [see page 2123]. The only difference is that, on account of its larger size, the arm of the player is less bent than when holding a violin. The bow, too, is held and manipulated in a precisely similar manner.

The Strings. Before beginning to play, the student should devote a little time to learning to put on a string and then to tuning the viola. The strings when bought usually contain sufficient for two lengths, with the exception of the covered strings, which are made to the size required. Strings will be found to vary somewhat in thickness; the exact gauge best suited to any instrument is a matter that can only be decided by experience. Having obtained a suitable string, proceed to make a knot at one end of it. Pass this through its proper hole in the tailpiece, and push the string in to the adjoining slot, which is too narrow to allow the knot to be pulled through. One end being thus firmly held, pass the string over its notch in the bridge and along the fingerboard to the peg. In the illustration, the four pegs, marked 1, 2, 3, 4, correspond respectively to the first,

second, third, and fourth strings, and on no account must a peg be used for any but its correct string.

The end of the string is now to be threaded through the hole in its peg, and the latter turned in such a direction that the string shall pass *over* the peg—not under. After half a turn, the end can be extracted from the box and held so that the string shall pass over it on each subsequent turn of the peg, thus holding it firmly, and preventing it from slipping. The string should be made to coil upon the peg in a direction tending towards the larger end. If the peg shows any tendency to slip in its socket, it should be pushed inward as it is turned; being made to taper at one end, this will have the effect of wedging it into its hole.

Tuning. The strings are tuned by increasing or decreasing their tension by means of the pegs. The more tightly the string is strained, the higher, of course, is the pitch.

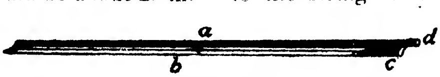
The A string is always tuned from some other instrument whose pitch does not vary. This is, of course, in unison with the second string of the violin, and is the note (arbitrarily) from which almost all instruments are tuned. From this fixed point, as it were, the other strings may be easily corrected, it being borne in mind that each is a perfect fifth from its neighbour, and that a perfect fifth is the most sensitive of all intervals; the slightest inaccuracy of one of its constituents produces a harshness that may be recognised by the most inexperienced ear. While the tuning is in progress the strings should be sounded with the bow; therefore it is well to be able to manipulate the peg with one hand, while the other holds the bow. The usual method of managing this may be learned by watching any violinist tuning his instrument prior to playing.

The viola must be firmly held by the chin. To assist this, a pad may be placed under the left lapel of the coat, beneath the instrument. The chin-rest also affords help in this matter, while the neck of the viola is to be supported in the crook of the thumb and first finger. This support should be sufficient to keep the instrument quite steady. Any attempt to grip the neck with the fingers, even between the forefinger and thumb, is inadmissible, and would, indeed, be fatal when we come to shifting to the higher positions.

The Bow. Now let us turn our attention to the bow. The different parts of this are shown in 2. The length should be about 29 in.

a is the stick, which is usually made of lance-wood or snake-wood.

b is the hair, which is fastened to the head (*c*).

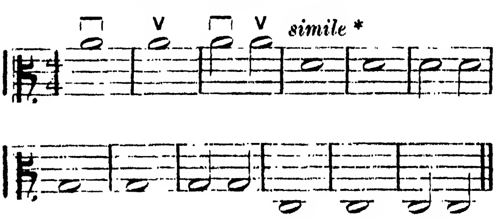


2. THE BOW

By means of a nut (*d*), which screws into the head, the hair can be made tighter or looser. When not in use the bow is kept loosened, and before beginning to play, it must be tightened by turning the nut. It must not be made so tight as to lose its elasticity, but tight enough to prevent the stick from coming into contact with the hair when playing *fortissimo*. On each occasion, before using, the bow should be rubbed over a piece of resin, care being taken that the ends as well as the middle of the hair receive their share.

The bow is held precisely in the same way as the violin bow, but one or two points may be reiterated. It should not be gripped too tightly, but held easily between the first, second, and third fingers opposed to the thumb; the little finger is used to balance the bow. Any additional pressure of the bow on the strings is produced by the middle joint of the forefinger. The hair of the bow must not be placed flat on the strings, but the bow must be turned so that the edge of the hair furthest from the player first comes in contact with the string. It is important when playing on the first string to remember to keep the elbow in, close to the side of the body; one of the commonest faults with beginners is to raise the elbow until the upper-arm is almost in a line with the shoulder. Apart from the awkward and ungainly appearance caused by this attitude, it is almost impossible to control the bow with due delicacy from this strained position.

Now try to play the following exercise very slowly and with an even tone. The sign ⊓ signifies a down-bow—*i.e.*, starting at the nut and drawing to the point; V is used to indicate an up-bow, from the point to the nut.



[* *Simile*—*i.e.*, in the same manner.]

Hold the viola and bow as directed, and bring the latter, at the end near the nut, on the A string, at a place approximately midway between the bridge and the fingerboard. The wrist should, at this point, be somewhat bent; the wrist-bone, that is to say, should be higher than the hand. Now draw the bow slowly across the string, endeavouring to keep the pressure on it perfectly even throughout the stroke. See, too, that the bow remains on the same part of the string throughout, and does not get either nearer to the bridge or to the fingerboard. Take care that the bow remains at right angles to the string all the time, and if, on nearing the point, it is seen to be otherwise, the fault will probably lie with the arm, which may have been moved from the shoulder joint instead of the elbow, thus swinging round the whole arm and causing the elbow to move behind the body.

This is a bad fault, and must be carefully guarded against. As a matter of fact, after half the length of the bow has been drawn, the upper-arm has very little to do, the greater part of the movement being caused by the unbending of the elbow. The wrist, also,

gradually unbends until, at about two-thirds of the bow, it is level, and during the remainder of the stroke it bends in the reverse direction—that is, with the wrist-bone lower than the knuckles. This movement will be found to occur naturally if the bow is kept straight and the arm near to the side.

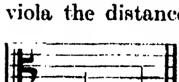
For the up-bow the movements are simply reversed.

The bowing for the other three strings is very similar. The chief point of difference lies in the elevation of the upper-arm, which is to be raised sufficiently to allow the bow to lie comfortably on the string.

Expression. So far nothing has been said about the sounds we are producing from our instrument. The intensity of the sound —*i.e.*, its loudness or softness—is governed, to some extent, by the speed of the bow, but principally by the degree of pressure exerted by the bow on the string (by means of the forefinger). When playing *pianissimo* the weight of the bow on the string is controlled by the little finger, which acts as a counterbalance. A difficulty to the beginner is always to start so that an unpleasant scraping shall not intrude itself; this seems to be caused by a combination of too much pressure on the bow and too slow a speed, but principally the former, and may be overcome by judicious attention to these two points. The exercise should then be practised with a *crescendo* and *decrescendo* on each note, beginning and ending quite softly and swelling to a *forte* in the middle.

As soon as a moderate amount of mastery over the bow arm has been attained, we may turn our attention to producing notes other than the open sounds. Before beginning this, however, it is necessary to insist that the student shall listen attentively to every note he plays; for we have nothing but the ear to tell us whether or no we are playing in tune. The position of every note must be found out and learned accurately; there must be no shuffling and sliding of the fingers to correct a faulty intonation. Therefore, let it be emphatically reiterated, *listen*, from the very beginning until the habit has been acquired of stopping notes dead in tune, and after that still listen, to ensure correct playing.

Now, it is easy to say that on an average viola the distance from

 is 1½ in., and

about ⅛ in. less, and so on. This may be quite true, but even the very beginner cannot put down his bow and measure off the distances upon the fingerboard. He must use his ear to tell when the note is sounding in tune, and then remember the positions of the fingers that gave the correct sound. If the student has small hands he may find G with the fourth finger rather an awkward stretch, but that is no reason for permitting the note to be played flat, or for substituting the open note. Let the little finger have the exercise it stands in need of, and in a very short time it will cease to give trouble.

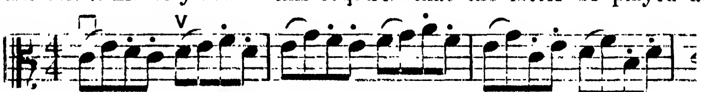
Space forbids the inclusion of exercises, but the student should, at this point, procure a book of elementary studies for the viola. Those by Hofmann may be recommended, or the "Viola School," by Hans Sitt, will be found useful. Both are published in the Peters Edition.

It is not necessary that a whole bow be used for each note as we have hitherto done. Several notes may be stopped, even those lying on adjacent strings, during the time the bow is travelling from one end to the other. A slur, thus:

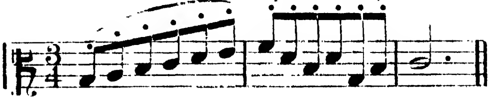
is used to indicate that all the notes under it are to be played in one bow. The smooth effect of this is termed *legato*, the word *staccato* being employed to indicate short notes played each with a separate bow; the latter are sometimes marked with a dot, thus:

A variety of patterns, formed of a combination of legato and staccato, is thus possible. Many of these require careful management of the bow to render them successfully.

In this example, more bow is required for the slurred notes than for the detached ones, and this requires that the latter be played at the

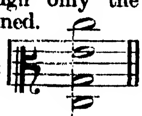
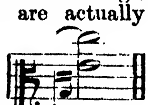


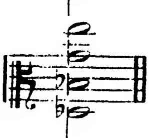
opposite end of the bow for each group alternately. A more difficult bowing is the following:

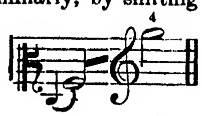
It would seem that three times as much bow is wanted for the *legato* notes as for the one *staccato*, but if this is done a very short time will bring us to the end of the bow, and make it impossible to continue without an ugly break in the music. The only way to overcome this difficulty is to take an equal amount of bow for the two unequal sections of the group—that is, a rather slow down-bow for the three slurred notes and a quick up-bow for the last note, taking the bow back to the starting-point. The use of the following sign

is to be interpreted thus: the slur indicates one bow for the six notes; the dots indicate that the notes are to be separated—that is, the bow must stop between each note. This is sometimes called *portamento*.

When we reach the use of sharps and flats our difficulties materially increase, for each finger has now three different positions to remember. Thus, on the fourth string, the first finger will, besides the D♮, play D♭ (C♯), half a tone below its normal position, and also D♯, half a tone above, despite the fact that this latter is the same sound as the E♭, which is taken with the second finger. The position of the hand should not be altered at all, merely the finger advanced or put back to a position midway between two consecutive tones. The other fingers have a corresponding series of extensions and retractions for stopping the notes a chromatic semitone on either side of their normal position.

It will be seen that by inclining the bow so as to touch two strings simultaneously, double notes may be played; the chief difficulty with these will be found in keeping the tone evenly balanced on both strings. Three, and even four, notes may be played almost together, by drawing the bow rapidly across the strings, although only the highest two are actually sustained.

Thus:  which sounds  never the reverse . It is more difficult when none of the notes are open ones, thus:  The intonation must be very carefully attended to.

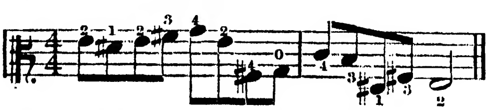
Still harder is this position:  But such chords are not very common.

Positions. The student will do well to confine himself for some time to the first position only, until he has acquired a very considerable mastery over exercises and easy pieces within his abilities.

If we shift the hand along the neck of the viola, so that the first finger is in a position to stop the notes formerly played by the second, and, in consequence, all the other fingers are also playing a note higher than previously, the compass will extend to F on the first string instead of E, and we shall be playing in the second position. Of course, the lowest note, D, on the fourth string is now inaccessible; we have merely transposed the compass a tone higher—not extended it. Similarly, by shifting the hand still a note higher, the compass will extend: 

This is the third position. In a like manner, the fourth, fifth, sixth, and seventh positions are attained, each situated a note above the previous ones.

There are several things to be learned afresh for each new shift. First, the position of the hand along the neck of the instrument must be remembered, so as to bring the fingers over their correct note positions. Secondly, an entirely fresh fingering has to be memorised and connected with its corresponding position; and here much confusion will result if we try to proceed to fresh difficulties before thoroughly mastering the earlier ones. Thirdly, as we advance to the higher positions the notes become closer together; they are no longer at the distances they occupied from one another at first; in the very high positions the fingers become uncomfortably close together, and there is consequently even less latitude for error than before. It is important that one position be thoroughly learned before studying another.

It is very usual, and the practice has much to recommend it, to learn the third position before the second. It is a more generally useful one, and has, furthermore, this advantage: just as, in the first position, the hand was at the end of the neck—the projection of the peg-box forming a guidance for the thumb—so now, in the third position, the hand is brought to the other end of the neck, and allowed to rest against the shoulder of the viola body. This establishes a fixed point of aim for the hand, which is not possible in any of the other positions, although in the fifth and higher the thumb should always cling to the viola in the angle of the neck. When the fingering of the third position has become tolerably familiar, exercises should be practised wherein it is combined with the first position. In changing from one to the other, the hand and finger—it is, perhaps, easiest with the first finger stopping its note—should be swiftly slid together, with no independent movement of either.

Mention should be made here of what is known as the half position. It is situated a semitone below the first position, and its use will best be seen from an example.



By playing this with the fingering shown, the passage becomes considerably easier than if played in the first position. From what has been written, the student should have no difficulty in learning the remaining positions, with the aid of a suitable book of studies properly graduated as to difficulty.

For an explanation of harmonics and much other matter, the student is referred to the instructions on the violin.

Viola concluded

VEHICLE BODY MAKING

The Bodymaker and Machinery. The Uses of Timber. Tools. Names of Parts. Joints Used. Getting out the Stuff. Framing. Panelling

continued from page 2731

By H. J. BUTLER

THE bodymaker is essentially a woodworker, although we see some types of railway waggons where metal is the constructional material. Motor-car bodies with aluminium panels and mouldings also require that the workmen should have some knowledge of the nature and properties of other substances besides timber.

The rail-carriage bodymaker depends largely on the preparation of his framing by the sawmill, his work consisting largely of what might be strictly called *fitting*. The coach bodymaker often has the heavier part of the "getting out" done in this way, but, taking it all round, the construction depends on his own manual skill. Again, in van building and in tramcar and omnibus factories, we see machinery playing an important part in the preparation of the stuff. Machinery itself is dealt with further on.

The Uses of Timber. Well-seasoned timber is the chief material required by the constructor of vehicles. Too much importance cannot be placed on the proper drying of the wood. For most purposes the natural and slow process of seasoning is the best. Different woods require varying periods in which to become fit for use, and the thickness of the timber is also a factor in determining how long it must lie. The nature and properties of timber are dealt with in another part of this work, but some of the varieties, with their uses, will now be given.

American Oak. Because of the length in which it can be obtained, American oak enters largely into under-frames, floor, and body framing, and into rails and pillars in railway work. It lends itself for bent work, and therefore may be seen in top rails carrying the roof. The varieties of European oak are used for panels and facias, as the medullary ray, being distinct and numerous, makes it ornamental in character. The wheelwright uses oak for heavy stocks, bottom framing, pillars and standards, also under-carriage framing, and beds of axles, especially if a wet load, such as brewers' grains, be carried. Tramcar door frames, seat laths, and trolley planks are of oak, as are also the chief members of the under-frame. It may be noted that tramcar and railway rolling-stock are generally made in the same works. The Great Eastern Railway Company have lately turned out omnibuses, but this is an exception. The style and construction of both are similar, and many of the terms used are identical.

English Oak. English oak, because of its tannic acid, corrodes any ironwork that may be fixed to it, yet it is the best of all oaks, its toughness being unsurpassed. The home-grown variety is used by the coach builder for glass frames. Whatever may be the claims of American wheels, English oak spokes have not yet been surpassed. The fireman, as he hastens up the escape bent on his merciful errand, treads upon the same material. The maker of trucks, hand carts, and barrows uses oak.

Other Woods. *Teak* is a railway wood, and is used for framing, panels, and disc wheel centres. Tram and 'bus bodies have also this wood in their framework. It is specially suitable for hot climates, and has a breaking strain about half as much again as oak.

English Ash is a coach-building wood employed for the framework. Public service vehicles are partly so constructed. Its strength, toughness, and elasticity can be utilised only when the timber is well protected. Ash may be bent like oak, and is used in similar positions. The hedge-grown variety, when not too old, is well adapted for under-carriage woodwork and felloes of wheels. American ash does the work of the British variety only to a smaller degree—at least, so the Englishman says. Van raves, fore-carriages, and bolsters, also most vehicle shafts and poles, are of ash. Panel battens, furring, or backers, though often of pine, are sometimes made of this variety of timber. The truck maker numbers it among his hard woods.

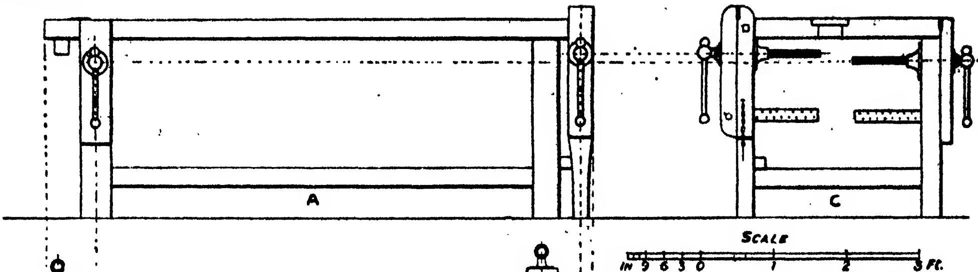
Elm is seen in van bottoms subjected to hard wear, and is used in coach-building for stocks of wheels. The wheelwright uses it for light stocks. Foot boards, seat boards, boot and body sides are also of the same wood, the last-mentioned when the work is finished in the natural wood. Stair treads and wooden van axle beds are sometimes of elm. This wood does not take paint well.

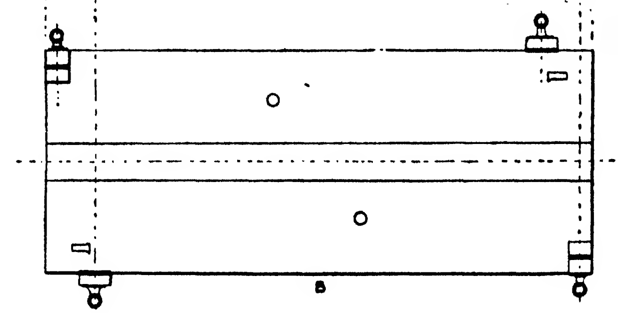
Canadian Birch foot boards, seat boards, boot and body sides and wings are used by carriage builders. The great width of this wood makes it suitable for van panelling. The interior decoration of railway coaches is often effected in *Sycamore* and *Walnut*. The coachmaker finds the latter useful in varnished cart sides.

Honduras Mahogany is pre-eminently a panelling wood in all types of vehicles. The beautifully figured *Spanish* mahogany is used in ornamental fittings. *Cedar* is used for panels in cheap jobs.

Whitewood and *Poplar* are panel woods used in America. In this country we use them in work that we do not wish to be expensive. The rocker panels of trams are of whitewood.

There are many varieties of *Pine*. The Canadian yellow pine and European brands are used for railway waggon sides, and for floor, roof, partition, and lining boards. In road vehicles they have similar uses, such as bottom, seat, lining, and roof boards, and the advertisement boards of trams and 'buses are of the same timber. Oregon pine is used for the sides of fire-





31. BODYMAKERS' DOUBLE BENCH
A. Side Elevation. B. Plan. C. End Elevation

escapes. When vans are double panelled the inside one is of pine.

Kauri pine has similar, though not so extensive, uses to the American and European varieties.

Pitch pine is used sometimes in tram cant rails, rocker rails, seat laths, crown pieces, and trolley planks. It is a suitable material for stair treads and stepboards. *Sequoia* is used alternating with pitch pine for seat slats.

The Tool Chest. The kit of tools required by a bodymaker is more comprehensive than that of the carpenter and joiner. The vehicle body constructor is in most cases a far more highly skilled workman, although he receives less wages than the man responsible for the woodwork of house and shop. The contents of the body-maker's tool chest varies greatly, yet the following is a representative list:

Chisels from $\frac{1}{16}$ in. to 2 in. broad
Gouges from $\frac{1}{2}$ in. to 1 in.
Flat gouges
Mortise chisels
Cold chisels
Draw knives (medium and large)
Axe
Adze
Two braces
Set of bits, in canvas or baize rolls, comprising centre, shell, spoon, nose, twist, shell gimlet, flat; snail's horn and rose head countersunks; turnscrew, rimer, and screw bits of various sizes
Shell and twist gimlets
Bradawls
Fiddle drill
Tool pad
Marking awls
Scrapers
Turnscrews
Brad punches
Smoothing, jack, trying, door checking, compass, adjustable, toothing, T, and grooving planes
Parting, beading, and listing tools
Checking filister
Shaft rounder
Jarvis
Draw bore pins, straight and crooked
Spanners
Wrench
Framing, bolt, and pin hammers
Coachmaker's vice
Bench stop
Cramps
Bench holdfast
Sash cramp
Files, various kinds
Pincers and pliers
Iron compasses
Oil can
Pencils
Tool bass
Oilstone and slips
Spare tool handles
Marking, cutting, mortise, and panel gauges
Steel squares
Sliding and spider bevels
Spirit level
Spokeshaves
Fence, boxing, and side routers
Saw pads
Keyhole, hand, panel, frame turning, bow, compass, tenon, dovetail, back, and Bettye saws
Mallets
Straightedges
Set square
Rule, marked English and Metric
Trying, winding, or fairing sticks
Ram's horn sweep
Name punch
The coach carver uses besides the ordinary carving tool, special tools of his own making

Fig. 31 shows a bench specially constructed for coachmaker's use. Such a bench should be made of English beech, with the exception of the centre plank. Both end and side vices have iron screws, slides, bearings, and face plates in the jaws.

Names of Parts. Although some names, such as *wheels, spokes, panel,* and *body* are used throughout the different branches, yet the greater ... undergo changes in various

bodies.

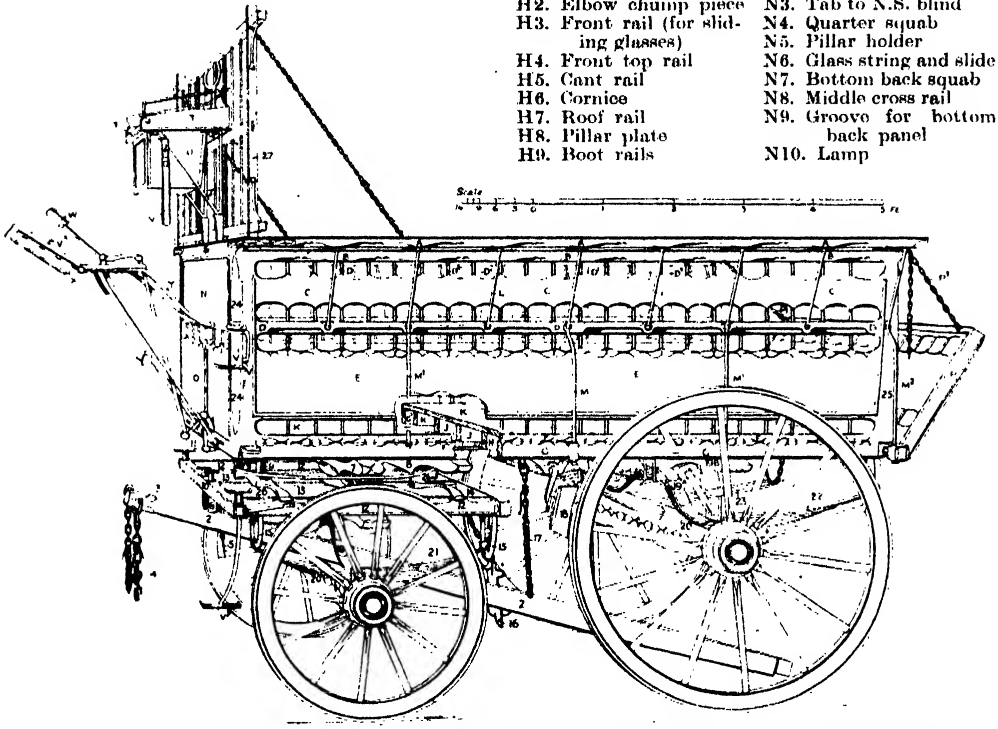
In **32**, **33** and **34** are illustrated three different types of vehicles, with panels removed to show the interior construction. In **32** we may see at a glance the general methods adopted by the van builder in the heavier class of work. The names of the various parts are as follow, and the reference letters and figures serve for identification:

A. Floating rave
B. Top rave
C. Name board
D. Middle rave
D1. Round iron pins
D2. Round iron pins, O.S.
E. Side board
F. False top side, or lining piece
G. Bottom, or main side
G1. Bottom or main side, O.S.
H. Hanging, or spring summer
J. Summer
K. Floor board
L. Floating rave stay
M. Central body staff
M1. Front body staff
M2. Hind body staff
N. Front name board
O. Front board
P. Tailboard
P1. Tail chain
Q. Hind earbreadth, or earbed
R. Front earbreadth, or earbed
S. Head rave
T. Dickey seat
U. Book locker
V. Ascending strap
V1. Ascending tread (upper)
V2. Ascending tread (lower)
V3. Ascending handle
W. Break treadle
X. Hinged footboard
Y. Landing board stays
Z. Dickey seat stays
2. Pole
3. Pole crab
4. Pole chains
5. Pin strap
6. Front pole socket
7. Top bolster
7A. Bottom bolster
8. Horn bar
9. Pedestals
10. Splinter bar
11. Splinter bar tread

12. } Guides
13. }
14. Hind bar
15. Globe scrolls
16. Dragshoe, drug shoe or skid
17. Wheel chain, lock, or tie
18. Brake block
19. Front check spring
19A. Hind check spring
19B. Hind check spring bearer
20. Wooden axle bed
21. Front side spring
22. Hind side spring
23. Drag prop
24. Front pillar
25. Hind pillar (gun-stock pattern)
26. Wood sweep pieces
27. Front loading rack

Parts of a Light Road Waggon. The lighter class of work is illustrated in **33**, and the under-carriage is typical of American practice. The waggon has a cut under for front wheels; it is hung on three springs,

A4. Moulding
A5. Fence rail
A6. Outside door handle (drop pattern)
A7. Inside door handle
B. Shut door pillar, O.S.
C. Front standing pillar N.S.
C1. Toe of C.
C2. Brass shut plate
D. Hind standing pillar, N.S.
E. Hind standing pillar, O.S.
F. Corner pillar, N.S.
G. Front light pillar, N.S.
H. Short bottom side, N.S.
H1. Top chump piece
H2. Elbow chump piece
H3. Front rail (for sliding glasses)
H4. Front top rail
H5. Cant rail
H6. Cornice
H7. Roof rail
H8. Pillar plate
H9. Boot rails
L9. Seat Valence bead
L10. Seat rail
L12. Boot side, O.S.
M. Door panel, N.S.
M1. Dash or dasher
M2. Dash handle
M3. Bracket tread
M4. Bottom arch panel
M5. Top arch panel (section)
M6. Top back panel
M7. Front side glass frame
M8. Door lining, or casing boards, O.S.
M9. Outrigger hinge
N. Door batten
N1. Silk blind, N.S.
N2. Silk blind, O.S.
N3. Tab to N.S. blind
N4. Quarter squab
N5. Pillar holder
N6. Glass string and slide
N7. Bottom back squab
N8. Middle cross rail
N9. Groove for bottom back panel
N10. Lamp



32. A 3-TON MARKET VAN, WITH PART OF SIDE CUT AWAY TO SHOW BOTTOM FRAMING

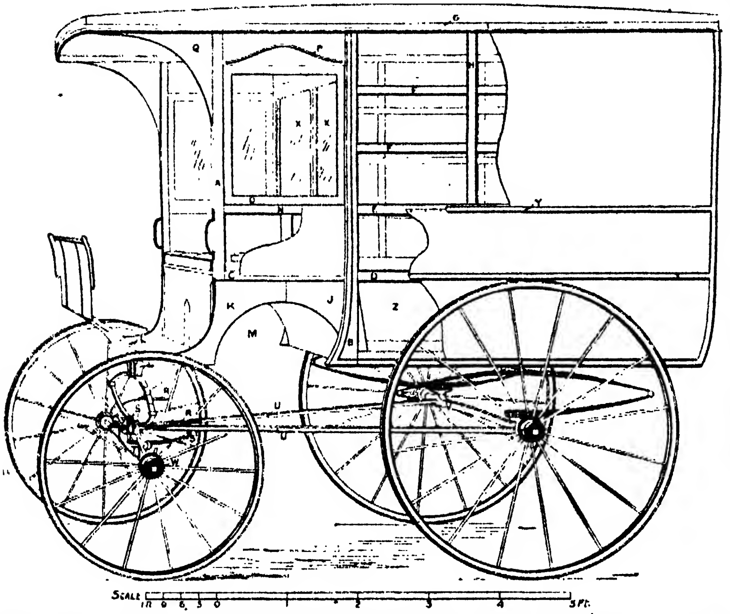
and has a plain double perch. The constructional details are as follow, and the naming follows American practice:

A. Front corner pillar
B. Coupé corner pillar
C. Sill
D. Belt
E. Centre bar
F. Guards
G. Top rail
H. Centre post
J. Rocker piece
K. Riser
L. Bracket piece
M. Wheelhouse
N. Window rail
O. Window frame
P. Drip moulding
Q. Head panel
R. Step tread
S. Head block
S1. Fifth wheel
T. Front axle bed
U. Double perch
V. Back axle bed
W. Hub
X. Window partition
Y. Pinned moulding
Z. Inside lining panel

Details of a Brougham. There are a great many parts in the construction of a double brougham, which are clearly set forth in **34**:

A. Hinge door pillar, N.S.
A1. Shut door pillar, N.S.
A2. Door top, N.S.
A3. Wasting round light
H10. Top arch panel (in. side surface)
J. Short bottom side, O.S.
K. Top quarter battens N.S.
K1. Bottom quarter batten, N.S.
K2. Bottom quarter batten, O.S.
K3. Glue blocks
K4. Bottom quarter panel, O.S.
L. Top quarter panel, N.S.
L1. Boot side, N.S.
L2. Heel board
L3. Bracket
L4. Well footboard
L5. Seat fall
L6. French driving box
L7. Seat border, or valence
L8. Seat board
P. Door bottom
P1. Body step tread, O.S.
P2. Body step cover, N.S.
P3. Body step cover, O.S.
P4. Step cover stay, N.S.
P5. Step cover stay, O.S.
P6. Step tread stay, O.S.
P7. Step tread stay N.S.
P8. Tail of pump handle
P9. Pump handle
Q. Rocker, N.S.
Q1. Glass frame (lowered)
Q2. Rubber buffer for glass frame
Q3. Glass frame rest
Q4. Bevel of glass in frame
R. Edge plate, N.S.
R1. Edge plate, O.S.
R2. Flap of edge plate
R3. Roof
R4. Flaps to dash iron
R5. Bolts retaining edge plate

R6. Hind carriage bar
S. Hind bottom bar
T. Front bottom bar
U. Front seat rail
V. Hind seat rail of front inside seat
W. Front inside seat board
X. Inside seat-board
Y. Hind seat rail
Z. Top back side battens
Z1. Top back centre battens or back light batten
Z2. Hole for back light
2. Felloe
13. Hind axle
14. Front axle
15. Tonguing piece
16. Framing piece
17. Top bed, or transom
18. Axle, or bottom bed
19. Horn bar
20. Futchell jaw
21. Adjustable splinter bar
22. Roller bolts
23. Circular shaft bar
24. Wheel iron
25. Back stays to wheel iron
26. Futchell stay



33. AMERICAN DELIVERY WAGGON WITH CUT UNDER FOR FRONT WHEELS

3. Spoke
4. Stock
5. Spoke face
6. Tyre
7. Front stock hoop
8. Axle cap
9. Top spring clips
10. Hind elliptic spring
12. Front elliptic spring
O.S. = Off side
27. Front felloe piece
28. Hind felloe piece
29. Wheel plate
30. Bottom spring clips
31. Spring blocks
32. Axle flap
33. Flap of bottom bed plate
34. Footboard stay
N.S. = Near side

Simple Vehicles. Figs. 35 and 36 illustrate two of the simplest forms of body-making. In the former we have a wooden bottom, while the superstructure is practically all metal work. The method of fastening the middle and bottom side and front rails is illustrated in A.

Fig. 36 is, again, merely a wooden bottom, with two sides and one end. This forms a delivery hand-cart for many trades

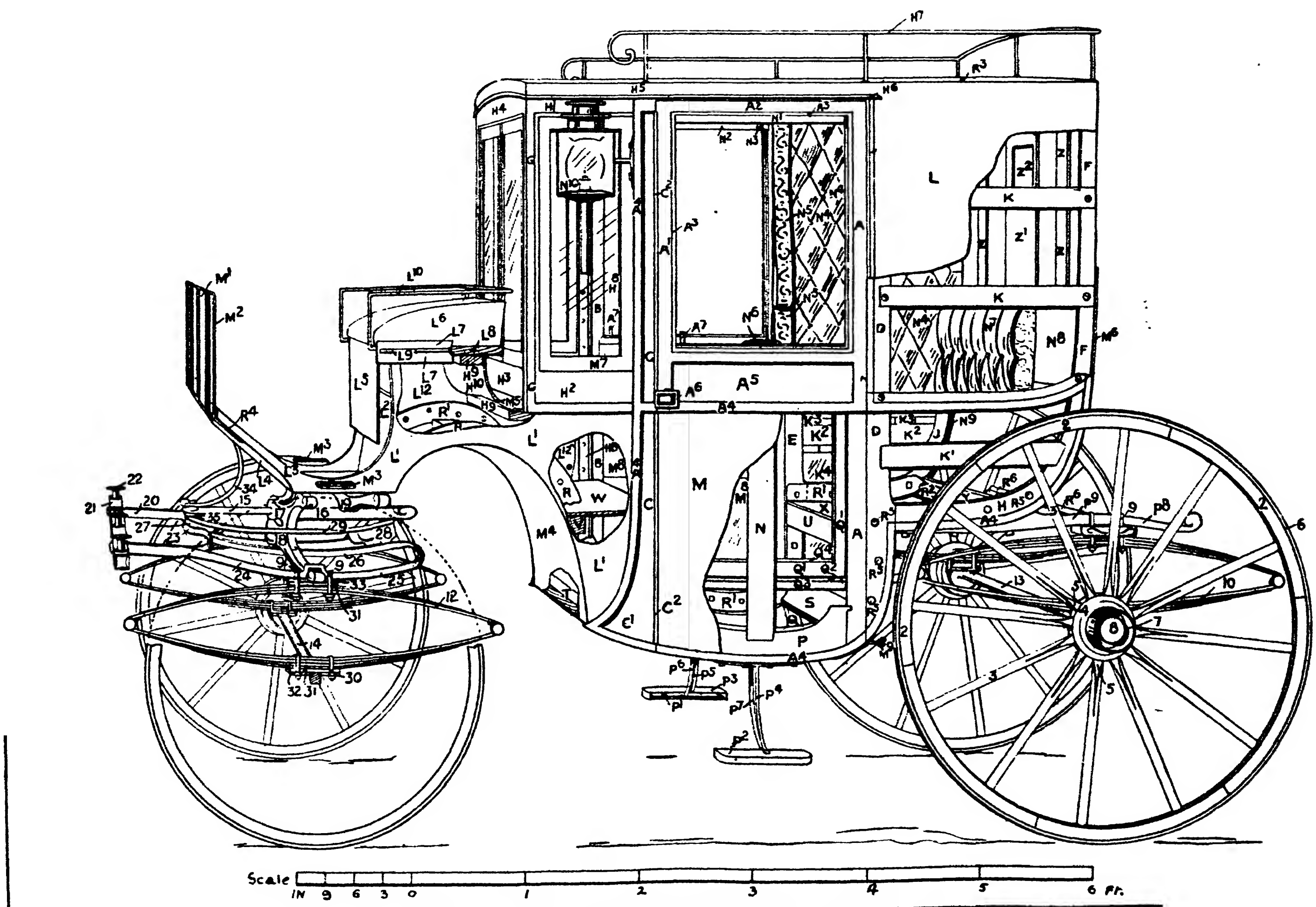
The Master Car Builders' Association of America has compiled a splendid illustrated dictionary which is an official vocabulary of terms used in building American rail and tram road cars. With its 149 large pages and close upon 5,000 detailed illustrations, occupying a further 374 pages, it forms a monumental work. That nothing has been overlooked may be gauged from the fact that the pillows and blankets of the sleeping berths are shown. Furnishing details, even to soap-dishes, are included. In the accompanying illustrations an attempt has been made to show the names of the chief parts of leading vehicles. Upright members are safely called pillars or posts, and those that lie horizontally are generally designated as bars or rails. The position of a piece often decides its name, such as top, bottom, middle, centre, or top back rail, while its duty [illegible] ascending step, or brake spring. Others, such as futchell, nunter, cant rail, summer, and rave, do not readily lead the uninitiated to their locality. The names of the vehicles themselves are, perhaps, more uniform, but Americans never talk of railway carriages or waggons. Everything is a car, sometimes a coach.

There a *caboose car* is here a *guard's van;* express and baggage cars are *luggage vans.* Motor-car people have from time to time lacked uniformity in the naming of their bodies. At one time, anything with a solid head was a brougham, and even now landaulettes are called landaus, and the term tonneau is applied to bodies whose plan shape is anything but a tub.

The French term *coupé* is often applied to the single brougham, and a three-quarter brougham is the same as a double or double-seated brougham. The terms *lorry, lurry,* and *trolley* do not seem to have any special distinction between them.

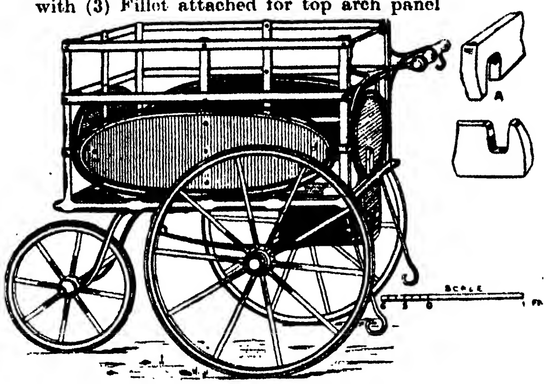
Apart from the terms, the spelling is again modified according to the person using it. The outside metal band of a wheel is written as tyre, tire, or tyer, the first being the most used, and various Americanisms, such as *center* for centre, *traveling* for travelling. Waggon is spelt with one "g" in the States, which form is, in this country, perhaps the more common, for in the leading coach-builders' catalogues we see "waggonette," and most van-builders write "wagon."

Joints, Concealed and Otherwise. We have perhaps seen the illustration of a chair cut from a solid block of timber by a patient savage. This was his primitive method, arising from an ignorance of the manner of joining the various pieces of timber. The making of joints is the most important work the bodymaker effects with his tools. All the joints shown in 37 occur in the body of a double brougham. A key to the references in the illustration is as follows:



34. CIRCULAR PATTERN SQUARE-FRONTED STATION BROUGHAM

A. (1) Cant rail and (2) Front standing pillar
B. Bottom boards
C. (1) Hoopstick and (2) Cant rail
D. (1) Quarter panel and (2) Top back panel
E. (1) Cant rail and (2) Corner pillar
F. (1) Front seat rail and (2) Hind standing pillar
G. (1) Front light pillar and (2) Front fence rail with (3) Fillet attached for top arch panel



35. MILK PERAMBULATOR
A. Method of fastening the middle and bottom, side and front rails

H. (1) Hind standing pillar and (2) Elbow
J. Glass frame
K. (1) Hind standing pillar and (2) Short bottom side

In road carriages, rail passenger cars, and public service vehicles, we build our body with the idea of hiding the joints as much as possible, in order that the interior and exterior neatness may be enhanced. Such a procedure necessarily calls forth much ingenuity on the part of the workman. He screws from the inside where possible, and must never show the end grain of oak pins in an outside mortise and tenon joint, because it will invariably show through the paint. Beads and mouldings are utilised to hide joints. In road and rail waggons, hand trucks, and barrows, it will be found that the body-maker is rather given, when making a mortise and tenon joint, to see that the tenon is brought through, and suitably carved and picked out with a fine line. But this does not apply to railway work; neither is the maker of railway vehicles ashamed of boltheads, for they are often brought into greater relief by painting with stars or crosses.

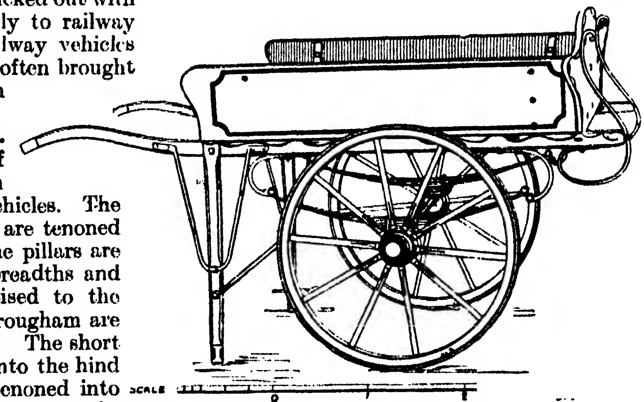
Different Types of Joints. *The mortise and tenon* is a type of joint that is greatly used in bottom framing of all types of vehicles. The main sides and summers in vans are tenoned into the carbreadths. Likewise, the pillars are stump tenoned into the hind carbreadths and main sides. The raves are mortised to the pillars. The standing pillars of a brougham are tenoned into the cant rail mortises. The short bottom side is sometimes tenoned into the hind standing pillar. The seat rail is tenoned into the hind standing pillar, and the waist rail is stump tenoned into the door pillars. In a gig, the stanhope pillar is stump tenoned into the bottom side. Not only in body framing does this joint find favour, but it is to be seen in undercarriage work, such as the tonguing and framing piece being mortised through the transom, the close futchells through the axle bed, and the back bar of a van fore-carriage is mortised on. Also, we must not forget that the spokes are fixed thus into the stock, hub, or nave, and "tangued" into the felloes. Therefore, the young man does well to practise this joint during his apprenticeship.

Lap Joints. The *lap joint* is simpler, and often more effective than its rival, the *mortise and tenon*. The term rival is used because the one is often substituted for the other. Certainly, the lap or check allows for less scamping by the workmen. In a brougham the standing pillars are lapped on to the rocker; similarly, the corner pillar is secured to the cant rail, and the short bottom side is often lapped into the hind standing pillar. In the same vehicle the elbow is lapped from the outside into the hind standing pillar and to the corner pillar. All kinds of battens are usually lapped. We see a *lap* and *tenon joint combined* in framing the shaft or draw bar into the shafts. Sometimes the hind carbreadth is lapped to the main sides in wheelwrighting. The longitudinal bars and intermediates in a railway carriage bottom are half lapped.

Rabetting and Notching. These joints may be regarded as varieties of the lap joint. In the coach body loft, boot sides are rabetted into the front standing pillars, foot boards are rabetted into the brackets, and bottom bars and bottom sides are similarly treated to receive the bottom boards. In fact, rabetting is a joint utilised in most vehicle floors. The top quarter panel of a brougham is rabetted into the hind standing pillar and elbow.

Hoopsticks are notched into the cant rail, and in the undercarriage the horn bar is often so fixed over the framing piece.

A *splice* is used in circular pattern broughams, preferably above the elbow in fixing the corner pillar to the short bottom side. The bracket and boot bottom side are similarly jointed, but often these are in one piece. In railroad vehicles, especially in the long types, the side members such as the cant rails (American equivalent *side plate*) and bottom sides, are, for economy's sake, jointed by a ship's, or, maybe, a parallel splice.



36. GROCER'S, FRUITERER'S, OR OILMAN'S HAND CART

We see *mitres* at the junctions of a top back and quarter panel and in top boot arch panels.

The *dovetail* is sometimes used in fixing together driving boxes and in the fixing of a circular fronted brougham, and in any instance where a box is part of the fittings of a vehicle, such as an ice-well in a drag boot or the ticket box on an omnibus.

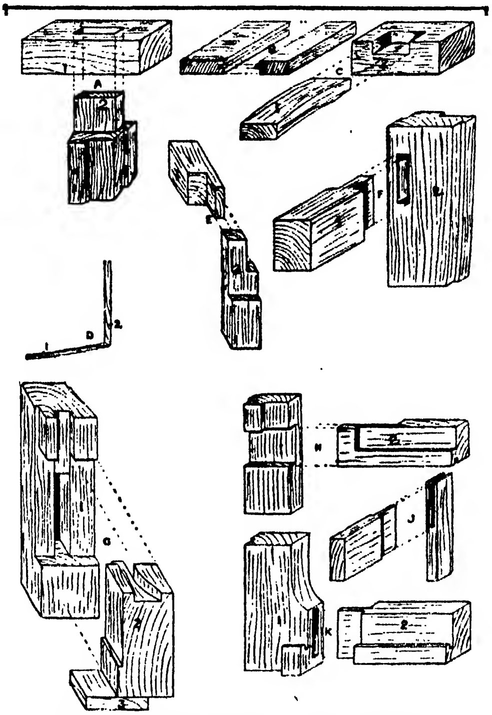
Panels are *grooved* into the surrounding framing, and boards are tongued and grooved together, or "matched," as it is sometimes termed. The *butt joint* simply relies on the bolt or screw for retaining the two pieces together, the one being merely laid on the other without preparation after the stuff has been planed up. In van work the front earbreadth is often butted on the summers, and the splinter bar butted underneath the front bar. Two panels are often butted edgeways before being covered with a moulding.

Mention must also be made of the *dowel joint*, used in the felloes of a wheel.

Getting Out the Stuff. The patterns for marking out are made of mahogany, whitewood, or pine. Some bodymakers are allowed to choose their own timber and do their own marking out, but the larger the shop the less does the bodymaker do in this department. In curved pieces or members having an angle in them, it is advantageous to mark out on a piece of timber that in its growth has followed more or less the line of the piece in question, so that we get the direction of the grain preserved during its length. This is compromised in the bending of timber by steam. Shakes and other faults in the timber must be avoided, and the marker out, having first decided the position from where his principal and largest pieces are to be cut, can then more economically plan out his smaller bars and rails that are made of the same kind of timber.

In marking the door pillars, we turn the outside to the heart of the plank so that any tendency to bend may serve to preserve the spring of the doors.

We must avoid waste, for timber is by no means cheap, especially if it be well seasoned. So the experienced man lays his pattern on the ever-varying shapes and conditions of planks and boards, and shifts them so as to occupy a position which will use up the timber to the best advantage, always having due regard to the direction of the grain, and giving due allowance for dressing up, bevels, etc.



37. JOINTS IN COACH BODY MAKING

Machinery. Probably the reader, if he has seen a good many years of service, has had the experience of getting out the stuff by hand. No doubt his first day with the frame saw is well remembered, and when he sees the rising generation having it all done in the saw-mill he feels that they will never make good workmen if they don't rough it as he has had to do. Even as we write, in the year 1906, there are two of London's leading coachbuilders whose machinery is practically confined to the typewriters in their offices. This may be a matter of surprise, yet the work that is done is of the best and can be turned out quickly.

Of course, the question of machinery has been considered, but it has been a sore point with the piece men when the necessary reduction in prices was suggested. If the firm introduces machinery they will expect the bodymaker to turn out his bodies more cheaply, so that, when added to the machinist's time and a proper allowance for machinery cost and maintenance, the price at least shall be the same.

Still, in shops like that at Wolverton, where the London and North-Western build their stock, the Stratford shops of the Great Eastern Railway, or in the United States, where one huge concern is capable of turning out in its combined factories 100,000 cars per annum, it would be absurd to haggle over the pros and cons of woodworking machinery. Here one sees the seasoned timbers brought from the adjacent yard where it is stored into the mill, where, by different stages, the stuff is sawn, planed, and thicknessed, and all joints are cut ready for the framing to be assembled.

The machines themselves are arranged so that the work may be conducted smoothly. No delay is to be seen where the hard timbers, such as oak and ash, come in at a certain door and are dealt with in progressive machines until they arrive at the entrance to the body shop in the shape of pillars and bars ready with mortise and tenon cut, rebates formed, etc. The pine and soft woods have a separate path of their own, but with the same destination. It will be readily understood that a machine that slabs a log of oak into planks, while others cut

it out into pillars with knives sharpened and set for the special purpose, cannot be conveniently arranged also to grapple with a deal, and convert it into floorboards, and tongue and groove them. So the larger the factory the greater the number of different machines each doing its own special work. As all the patterns are used in the saw mill, we should expect to see in a well-arranged shop the pattern-makers' shop in the immediate vicinity.

Framing. For the use of either machinist or bodymaker, the stuff after having been cut to shape must be given a face side. From this true surface the piece is squared and all bevels, etc., taken. Then the position of the joints are marked, which naturally demands a thorough mastering of the drawing. It is a trite saying, "To cut once and measure twice," rather than the opposite expedient. Mortises and tenons should be gauged at the same time. It is a good plan to saw outside the gauge marks on the tenon so as to ensure a tight fit, while it is good practice to cut the mortise a little deep, so as to make sure of the tenon coming well up to the shoulder. There is a great diversity of opinion as to the ways of framing. Attempts have been made to standardise sizes of timbers, position and strength of ironwork and general dimensions, but as yet little attempt has been made to bring into line of standardisation the joints to be used, their dimensions and fixing. Apart from this, the actual procedure of fitting together differs according to the man's training. The framing having been fitted together and found accurate, it is taken apart and the more delicate work of boxing out, rebating, grooving, and beading is proceeded with. The panels are fitted, the hinges let in, and the crossbars framed in. In a landau we should weight the body and screw a strong stretcher across the pillars, so that we may fit the edge plate to the shape of a fully loaded body, and consequently ensure properly shutting doors.

Panelling. Though some of the panels have to be put in before finishing the framing, it may generally be considered as a following process. Not only do we often desire a wide panel board, but it is necessary that a good length of timber be available. Tram, 'bus and rail car bodies demand large panels, especially if there are few vertical mouldings which are useful to hide a join. It can be easily understood that the larger the panel the harder it is to get it free from blemishes. Panel board must be well seasoned, otherwise it will shrink in the grooves of the framework and let in the wet, for the white lead used in the fixing is not meant to allow for shrinkage.

A well-fitting panel acts as a girder to the framework. To the inside surface of a panel is glued a special canvas which has the effect of greatly strengthening the work, and keeping it in shape. It is also blocked round the edges as well. This makes the job yet more rigid. Much of the panelling in the United States may be regarded as matchboarding. A 36 ft. box car whose depth of body is 8 ft. 6 in. does not lend itself to being panelled, and in America there is no great liking for mouldings on freight cars. The outside panel, or sheathing, of a passenger coach is also so treated. Perhaps the vertical lines produced by the junction of the board tends to take off the length of the cars.

In van work we see pantechnicons, refuse waggons, sling vans, and other large types with made-up panels, and, where an inside lining is used, we usually find it so constructed.

In motor work we have steel, iron, and aluminium used as panels besides the all-steel rail cars used here and in the United States. It will be understood that the motor bodies with curved corners and deep sides take up a huge piece of sheeting when a large area is unbroken by mouldings. The fitting of the panels to Roi de Belges bodies has been relegated to the metal worker, and the large firms, especially French houses, employ quite a number of these special workmen. The return sweep means careful hand hammering, while the single sweep may be bent to shape with less experienced hands. The larger the panel the more expensive will be the repair bill in the event of damage. Wood panels built up in sections are now used in motor-car work.

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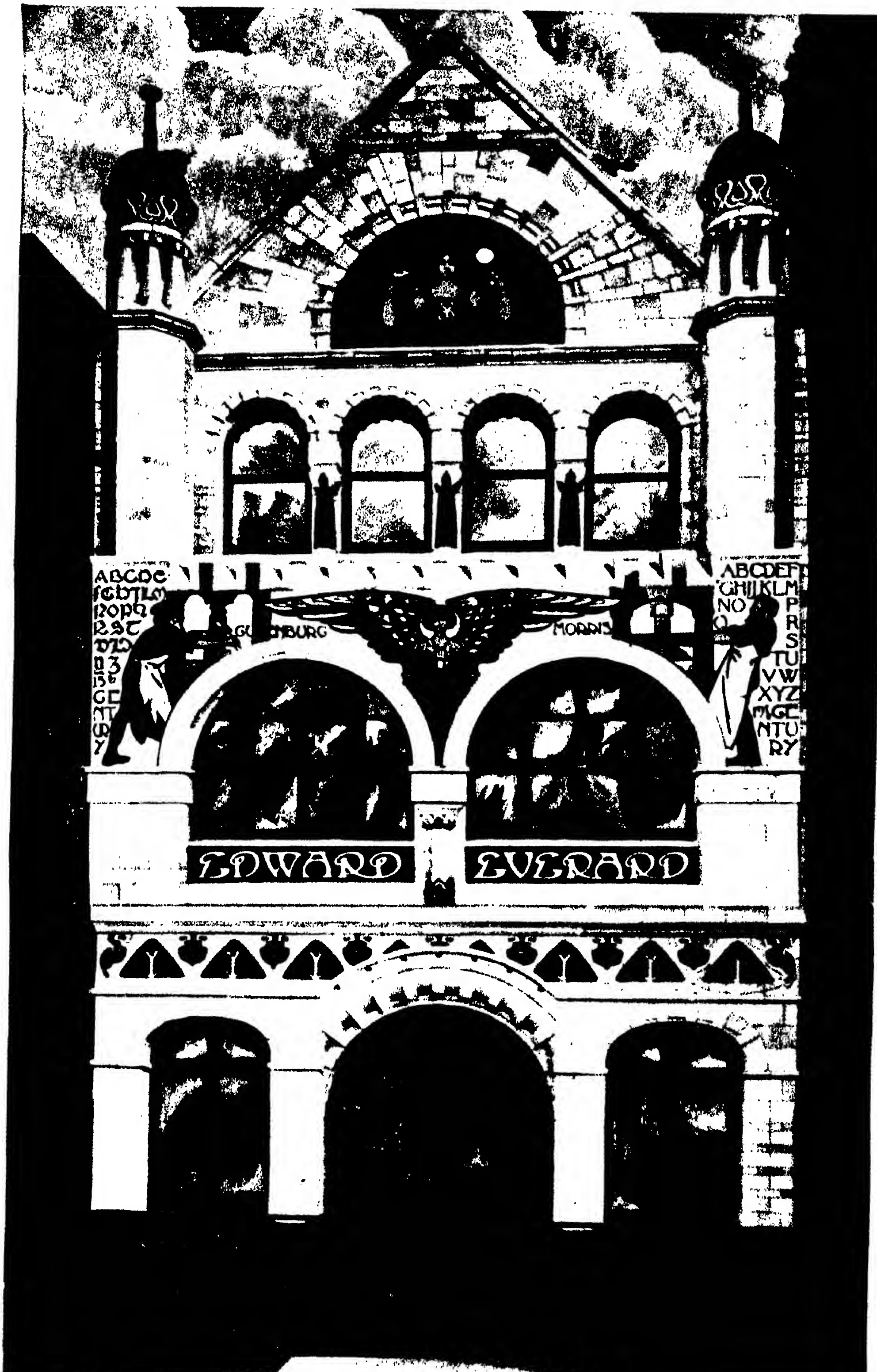


THE USE OF GLAZED TERRA-COTTA IN BUILDING

MASONRY

General Characteristics of Building Stones. Tools Used for Setting Out and Dressing Stones. Different Styles of Finishing Surfaces

Continued from page 2784

By Professor R. ELSEY SMITH

THE work of the mason is second to no other trade in importance, and though it is possible to form buildings with walls entirely built of brick, the finest architectural efforts in all ages have relied largely on the skill of the mason for their realisation. The stone on which the mason works varies greatly in its quality and properties, and consequently in its method of treatment. An account of a considerable number of the building stones in ordinary use will be found on pages 528-534, and the nature and appearance of these stones are there described. There are scattered through this country a great variety of stones which are suitable for building and used locally, but which are not widely known. Many of these may be advantageously used in the locality in which they occur, but are not to be found described in any general work of reference on building stones, and it will be well, therefore, to refer briefly to the characteristics that should be looked for in any good building stone.

Durability. Any stone, to whatever class or group it may belong, if it is to be used for building a permanent structure, must possess the character of a durable stone—that is, the power to resist the action of the atmosphere and other external influences. These influences are by no means in themselves uniform in character, and depend partly on locality and partly on the position in which the stone is employed. In many manufacturing towns the atmosphere is charged with a large proportion of acids, produced in the course of manufacturing processes and liable to attack certain classes of stone more than others. In such situations, it is a fatal mistake to employ a stone that will not resist the attacks of such acids, because it is of beautiful colour or easily obtained or worked. The stones most affected are those containing carbonate of lime or carbonate of magnesia. Even in the country the air is not absolutely free from the presence of acids, and in particular of carbonic acid.

Effect of Rain. The rainfall is an important consideration, as it is largely instrumental in washing the acids in the atmosphere into the stone, and wet weather succeeded by frost is a powerful influence in disintegrating stonework; the moisture freezes in the pores of the stone, and, expanding, splits off portions of it. Even without frost, wet is a destructive agent, especially when stone is used in parts of a building to which the air and sunshine cannot have access, as in the case of internal courts. But a high wind is apt to drive the rain into the stone on exposed situations, and so assist decay, and in sandy neighbourhoods it is further apt to eat away the surface of the stone by driving particles of sand against it.

The disintegrating influences are therefore numerous and various, and if, in spite of them, the stone is to be durable and is to *weather* well—that is, to resist the influences of the weather to which it is exposed—it must be carefully selected not only with regard to its chemical composition but to its structure also. Generally speaking, stones that are crystalline in character, as, for example, marble, will weather better than those of almost identical chemical composition which are non-crystalline in character—as, for example, chalk.

Hardness. For many purposes it is essential that the stone employed should be hard, especially when exposed to constant wear or repeated shocks; in general all salient angles are usefully protected by building them in a harder material if they are at all exposed to such influences, and all stone exposed to the action of water should be hard in character. In selecting a hard stone durability must not be forgotten. It does not follow that a hard stone weathers better than a soft one; indeed, the contrary is sometimes the case, depending on the composition and structure of the two stones.

Strength. *Strength* is for many purposes of very great importance. In most cases the resistance of stone to crushing—that is, its strength in compression—alone is tested, but many stones, such as lintols, are subject to cross strain and more rarely a stone is subject to tensile strain, as in the great stone pendants in the roof of Henry VII.'s Chapel at Westminster which support the conoids of the vaulting.

Where a concentrated load is to be borne by a detached pier, as in the columns supporting an arcade, the resistance of the stone to crushing, if not known, should be ascertained by testing; the actual load should not exceed one-tenth of the experimental crushing load. For ordinary walling the weakest stones are more than amply sufficient; even a weak sandstone will resist a crushing load of 120 tons to the foot, and the resistance to crushing varies from this point up to as much as 700 tons per foot in the case of some granites.

Facility in Working. This is a matter that very directly affects the cost of production; the original cost of stone, except in the case of specially rare and beautiful stones, depends more on the cost of labour in quarrying and transport than on any actual value in the stone itself. The cost of working up the stone in masonry also depends directly, for work of the same character and elaboration, on the labour that must be expended upon it. The quality

of facility in working must be borne in mind with particular reference to the class of work it is desired to produce. If the work be of a plain, massive character, a stone that is less easy to work may be selected than in the case of work full of elaborate moulded detail and perhaps carving. Hardness and resistance to the cutting tool are not the only points in considering facility in working, for we must study also the possibility of obtaining blocks of the size required for the particular work, the soundness of the stone and freedom from flaws, vents, veins of hard material, etc.

Colour and Appearance. For architectural work the colour of the stone and the quality of the surface texture it will exhibit is often a matter of great importance. The texture will depend on the kind of tool used in dressing the stone and the manner in which it is employed, and this necessarily depends upon the nature of the stone. But it is of great importance that these qualities should be practically permanent, and it is useless to select a stone of the most delightful and appropriate colour only to find that the surface is, within a few years, disintegrated.

Weight. For certain purposes the weight of a stone is an important element in its selection. For foundation work a heavy stone is often desirable, especially if the building be liable to shock such as arises from the action of the sea; but for vaulting and similar positions, lightness is a great desideratum if it can be combined with strength.

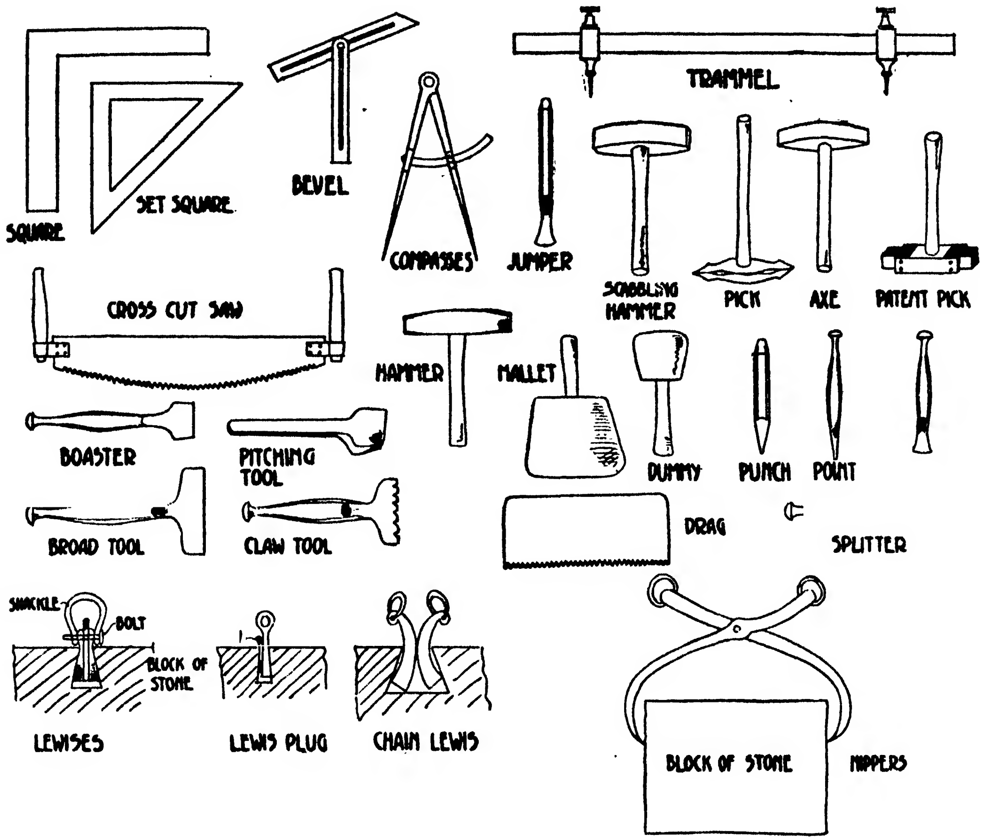
Quarry Beds. The position in the quarry affects many stones to a very great extent. Fig. **53** [page 531] gives a typical section of a Portland stone quarry, from which it will be seen that, quite apart from the top layers of another character altogether, the Portland stone itself occurs in several well marked layers. Of these *the Roach* is the first bed that is of much use for building. It is marked by the presence of the shell known as the *Portland screw* [**54**, page 531], but though strong and heavy, this bed is useful only for plain work such as foundations, as the surface cannot be brought to a fine face. Immediately below this occurs the very useful and valuable *Whitbed*, which is obtainable in very deep large blocks if necessary, and can be finely worked. Below, again, is the *Basebed* or *Bastard Roach*—of little value for external work as it weathers badly; and finally the *Basebed* or *Bestbed*, yielding what is for many purposes the best stone in the quarry, but it does not weather as well as whitbed, and is more suited for internal moulded and carved work. In other classes of stone the same difference between different beds may often be noted, and it is therefore necessary with many kinds of stone to specify the bed as well as the quarry from which the stone is to be obtained, or to require that it should be quarried from those beds best suited to the work to be executed. In large and important work it is useful to employ an experienced man to superintend the quarrying, as—notwithstanding the difference in quality between different beds, the difference in appearance is often difficult to detect after the stone has left the quarry.

Seasoning. Most stones contain a large amount of moisture termed *quarry-sap*, and the process of seasoning allows this to dry out; this is particularly important with the softer stones, which, if exposed to frost before being seasoned, may become disintegrated through the sap freezing. This process must be a gradual one, and is, with some stones, accompanied by a hardening of the surface of the stone.

Natural Bed. In the case of all stones that are *stratified* or *laminated* it is of great importance that they should be laid so that the natural bed—*i.e.*, the lines of the strata as originally deposited—are parallel to the horizontal bed joints in ordinary walling. So placed they are capable of supporting greater loads than if these strata were placed on edge; they are also better able to resist the attacks of weather than when the strata are placed not only on edge but parallel with the face of the wall, as they are then particularly liable to attacks by rain and moisture and are apt to flake off. In forming the voussoirs of arches, the natural bed should be placed perpendicular to the face of the wall and at right angles to the line of thrust in each stone. In the case of projecting undercut cornices and strings the natural bed should be placed vertically and perpendicular to the face of the wall. In such situations, if placed horizontally, the projecting members would be liable to be attacked by the weather and to flake off. In some stones the position of the natural bed is readily detected by the eye, especially if the stone be wetted, but in many it is difficult to observe when the stone is removed from the quarry, and in some it can be ascertained only by actually working the stone with the chisel. The mason can detect whether he is working along or across the bed in somewhat the same way as a carpenter can tell if he is working with or across the grain of timber.

Examining and Testing Stone. If it be desired to employ a local stone, of which little is known, for a building, much may be ascertained from a careful examination of the stone and some simple tests; but if a chemical analysis or test of the resistance to crushing be required, samples must be submitted to experts in these matters. As a rule the stronger, denser, and least porous stones of any class will weather best unless there should be any element in the stone specially open to the attacks of acids in the atmosphere in which it is to stand.

Newly broken pieces of stone, if examined with a strong lens, should appear bright and clean, not dull and earthy. The amount of absorption may be readily tested by carefully weighing a piece of stone, soaking it in water for 24 hours and again weighing, when the water absorbed is shown by the increase of weight. This should not exceed 1 per cent. for granite; 8 to 10 per cent. for sandstones; and 8 to 17 per cent. for limestones. A test to determine if there is easily dissolved earthy matter in the stone may be made by placing some small, freshly made



129. VARIOUS TOOLS USED BY MASONS

chippings, which should be made from a moist stone, into a glass about one-third full of clear water ; after standing for at least half an hour, the glass and its contents are agitated. If the stone be well cemented the water remains clear, but if the specimen contain loose uncemented material it becomes cloudy.

The stone may also be soaked for several days in a solution containing 1 per cent. of sulphuric acid and of hydrochloric acid; and it will be seen if there is a tendency for these acids to attack the surface of the stone. A drop or two of the pure acid, if placed on the stone, will produce effervescence if there is present much carbonate of lime or carbonate of magnesia.

Observation of Existing Work. A practical method of judging the qualities of a stone is to observe any old buildings in the neighbourhood of the quarry that have been constructed of the same material, or stones that have been cut and left in the quarry. It is necessary, when possible, to ascertain the bed that has been used and an examination of the surface will show if the tool marks remain sharp or if the surface has perished. The stoolings of jambs and mullions, the throatings of cills, and the under side of overhanging mouldings, should be specially noticed, as they are the portions most liable to attack ; if these are found to be in good condition considerable reliance may be placed in the stone.

Masons' Tools. The mason must be able, not only to work stones, but, to some extent at least, to set out work, and his appliances include instruments to assist these operations [129–131].

The *mason's square* is of an L shape, the arms unequal and making a true right angle. It is cut out of sheet iron and made in different sizes and is used for testing the correctness of two faces required to be at right angles. He also uses *set squares* of iron, brass, or zinc, usually formed with two angles of 45° and with the centre open. The *bevel* consists of two sheets of metal, each having a slot extending along the centre and a thumb-screw by which they can be fixed at any angle. *Compasses* are also used, and are often made of iron with sharply pointed ends and a thumb-screw, which works against a quadrant bar, so that the legs can be fixed at any angle. A beam with two compass points, which can be moved to and fro and fixed where required, and which are best made of bronze with steel points. It is used for curves of larger radius than can be set out with a compass. The beam may sometimes be required of great length, and it is then termed a *trammel*. All these are used for setting out work on the actual stone,

and a sharp pointed style is required for marking outlines. A *spirit level*, similar to a bricklayer's level, is required in setting stones, and sheets of zinc are necessary from which the *templets* or *face moulds* used in preparing blocks are cut, and for which No. 9 gauge zinc is usually employed.

Different classes of stone are worked up by the mason by different sets of tools depending on the nature of the stone to be dealt with and the appearance intended to be given to the surface.

Cutting up Granites. Granites are usually quarried with the use of wedges for all sorts of building purposes, but are blasted when required for road metal; they are split up into blocks of the required size also by wedges. The outline of the block is marked in all exposed faces, and a series of holes are drilled into it a few inches apart and penetrating only a short way. A long, very heavy chisel is used for this work, with a cutting edge, which is wider than the handle so as to clear itself easily. This is termed a *jumper*, and is used by raising it vertically over the hole to be cut, and letting it drop on the surface, which is gradually cut away. Into each of these holes, which are disposed in straight lines on each face of the block, a pair of iron *feathers* is inserted; these consist of thin concave pieces of iron, and a steel plug is placed between them; it is circular on plan and tapers towards one end. Water is usually poured over the stone, and the plugs are driven in till quite tight, and are then rapidly struck in succession till the block splits off. The subsequent dressing of the block is usually carried out at the quarry, a plan which in the case of granite has several advantages. The stone works more easily when first quarried. Machinery, which cannot be erected for any particular building, is available at the quarry for saving labour; there is a considerable saving in the cost of carriage if all the superfluous stone is removed. The chief drawback to this method with softer stones is the liability to damage in transit, but granite is so hard that this is much reduced.

Tools Used for Dressing Granites. Granite is sometimes sawn with a frame saw [130] into thin slabs, but the process is very slow. In dressing the stone, very heavy tools are used and considerable force is employed. The tools are swung or lifted and the force of the blow is due to the weight, or momentum, of the tool, not to the use of any hammer or mallet. The *scabbling hammer* weighs about 22 lb., and is used for the rougher work of knocking off large lumps and reducing the blocks to approximately the required shape; but, for certain classes of work, the exposed face may be left from the scabbling hammer and then presents a rough, bold appearance, which is described as *hammer dressed*. But all bedding surfaces must be reduced to a finer surface, and the *pick* is next used. This is also, in form, like a hammer with a pointed end, and weighs about 14 lb. A very much closer and more even character is given to the surface so worked, which is described as *picked* or *close picked*, if it be brought to a still finer face. It may be afterwards worked with an *axe* weighing about 9lb. The marks of this tool show on the surface in parallel lines, and the surface is described as *single axed;* a more careful description of the work of the same class is termed *fine axed*. The finest surface left from a tool is termed *patent axed*, and the tool for producing it consists of several strips of steel, each with a cutting edge, which are bound together and fixed in a handle; the fineness and closeness of these irons vary for different classes of work, the number of cutting edges to the inch depending on the thickness of the strips of steel.

Polished Granite. If granite is to be polished, the surface is brought to a fine face by the tool, and is then rubbed under an iron rubber with fine sand and water, subsequently with emery, and finally with putty and flannel. This work can be carried out by machines, except in the case of stopped mouldings, which must be worked by hand. The effect of polishing is to give brilliance to the surface and to increase the effectiveness of the rich colours which often occur in granites. For cylindrical work such as columns and balusters very powerful lathes are used for reducing, dressing, and polishing the stone.

Granite is used in building where its great weight and strength, its hardness and good weathering qualities, will be of special service; but these qualities are of more value to the engineer than the architect, who rarely requires to avail himself of them fully. But it is much employed in architectural works of a large class for its fine monumental appearance, and in certain situations for the rich colouring which many varieties possess, especially when polished. For particulars of several kinds of granite see page 529. The weight of granites varies from about 160 lb. up to 210 lb. per cubic foot.

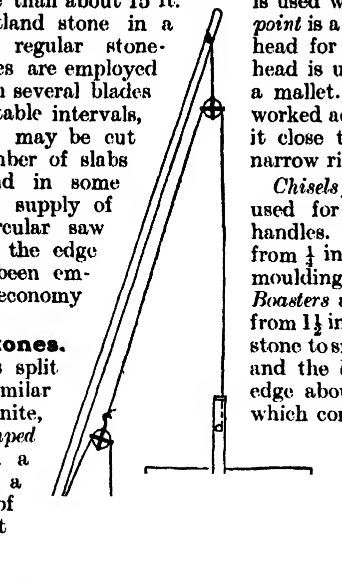
True Bedding. It is of great importance in all classes of stone that the horizontal beds which receive the superincumbent load should be true, and lie wholly in a plane to secure an even bearing; but it requires good workmanship to secure this in large blocks, and essentially so in the case of granite. It is essential to secure this, otherwise, if the bed be worked hollow in the centre, the outer portions only will receive the entire weight which the architect or engineer may have relied in his calculations on being distributed over the whole area, and, as a result, the safe load on those parts that actually receive the load may be exceeded, and fracture may take place.

Tools for Cutting Up Freestones. For cutting up blocks of freestone a *cross-cut saw* may be used for softer stones; this consists of a plate of steel, the lower edge curved and provided with large teeth coarsely set; a wooden handle is fixed at each end, and it is worked by two men, one standing on each side of the block to be cut.

For harder stones, a *frame saw* [130], consisting of a strip of iron usually about 4 in. by $\frac{1}{10}$ in., without any teeth, is employed; this is fitted

in a wood frame having two ends and a stretcher piece. The saw is fixed at the lower extremity of the ends, the stretcher piece is placed near the top and adjusted with packing pieces, if necessary, and the upper extremities are held together by wrought-iron couplings, which can be tightened up by a union screw. A pole is erected and fixed in position vertically over the block to be sawn, and near the top a pulley is secured by a chain. A cord is fixed to the frame of the saw, and passed over the pulley, and to the lower end of it a second pulley is fixed. A second cord is passed over this pulley, one end of which is secured to the foot of the pole, and from the other a weight is suspended which will to a great extent counterbalance the weight of the saw and frame, leaving its effective weight at about 10 lb. This arrangement [131] permits of the frame being drawn to and fro without ever escaping from the effect of the balance weight.

A small water tub stands on the block, the water trickles from an opening near the bottom over a drip on which the cutting sand is placed, and carries it into the cut; the saw is drawn to and fro by hand, and the stone is slowly cut through by the action of the saw-plate combined with the sand and water; but a good sawyer does not cut more than about 15 ft. to 20 ft. super. of Portland stone in a day of 10 hours. In regular stonemasons' yards large frames are employed worked by steam, in which several blades may be fixed at any suitable intervals, so that a block of stone may be cut up into any suitable number of slabs by a single process; and in some cases where a very large supply of stone is required, a circular saw formed of an iron plate, the edge set with diamonds, has been employed with an immense economy of time.

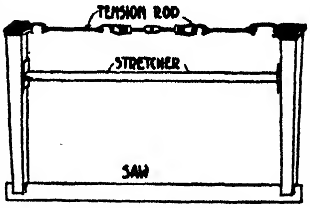


131. METHOD OF WORKING FRAME SAW

Splitting Freestones. Freestones are sometimes split into blocks in a manner similar to that described for granite, but the holes are not *jumped* as in granite, but cut in a wedge-shaped form with a punch. The wedges are of iron, and have a blunt point so as not to reach the bottom of the hole, and must be inserted and kept perfectly upright. They are gently tapped with a heavy hammer till each has got a grip of the sides of its hole, and then a series of heavy blows are given successively to each wedge till the split takes place. Sometimes hard-wood wedges are driven into the holes, and then saturated with water, when the swelling of the wood suffices to split the stone.

Tools for Dressing Freestones. The tools used for dressing freestones are numerous, and for the most part different in character from those used for granite. The stone is more easily worked, and the force of the blow is not derived from the momentum of a heavy tool, but, with a few exceptions, from blows struck with a hammer or mallet.

The *hammer* is of steel, weighs about 5 lb., and is used mainly for knocking off waste with a *punch* or *pitching tool*. A smaller hammer, weighing 3 lb. or 4 lb., is used with the cup-headed tools, especially in carving lettering and similar work. The *mallet* is of hard wood, and has a circular head, slightly tapered, and a short handle, and is made of various sizes and weights, and is used for striking the cutting tools. A smaller mallet, termed a *dummy*, similar in form, but made of lead or zinc, and weighing 3 lb. or 4 lb., is used with soft stones.



130. FRAME SAW

A *spalling hammer*, weighing about 16 lb., is used with the harder freestones for knocking off waste in the case of large blocks; but, as a rule, the *punch*, with a cutting edge about ¼ in. wide, is used with the hammer for this purpose. The *point* is a similar tool, but with a special flattened head for use with the mallet, which form of head is usually provided for all tools used with a mallet. It is employed after the punch, and is worked across the stone in regular lines, reducing it close to the finished face, but leaving it in narrow ridges.

Chisels are of various forms, but, except those used for soft stones, they have no wooden handles. They are made with a cutting edge from ¼ in. to 1½ in. wide, and these are used for mouldings, narrow surfaces, and sunk work. *Boasters* are of the same form, but have an edge from 1½ in. to 3 in. wide, and are used for dressing stone to smooth faces, and for finishing mouldings; and the *broad tool* is similar again, but has an edge about 4 in. wide, and is used for *tooling*, which consists in working across a plain surface with regular and parallel lines, which are left and give a distinct character or texture to the stone surface. All these chisels are used with a mallet, but small chisels with a hollow or cup-shaped end, termed *splitters*, are used with a hammer for carving and lettering and in working marbles.

The *claw tool* is made in various sizes. In form it is like a boaster, but the edge is provided with teeth which may be about ⅛ in. from point to point for hard stones, and for soft stones from ¼ in. to ⅜ in. This tool is used after the punch or point for dressing down surfaces to a finer finish. The *pitching tool* somewhat resembles a boaster in form, but it has not a cutting edge, but a thick, bevelled edge; it is used with a hammer in the early stages of dressing a stone, for knocking off or *pitching* the larger

irregularities and generally for removing all waste stone.

For finishing soft freestones a *drag* is employed. This is formed of a broad piece of sheet steel, the edge of which has teeth cut upon it. This tool is made in three different degrees of fineness, and termed *coarse, second,* and *fine drags.*

Methods of Lifting Stones. For many classes of masonry the stones are larger and heavier than one man or even several men can lift. For lifting and setting stones of moderate size a block and fall may often be rigged up on the ordinary scaffolding; for larger stones a pole or standard may have to be rigged up to hold it. In regular masons' yards a *gantry* carrying a traveller is generally used. By its means stone from any part of the yard may be lifted and deposited at any desired point [73, page 1173]. In setting masonry on important buildings it is now usual to employ a derrick on a lofty platform [71, page 1173], which not only serves to lift the materials from the road to the parts of the building where they are to be used, but may be used in setting blocks of large size.

All stones requiring to be lifted must be provided with some hook or other means of attachment to the lifting apparatus, and as these are required only for temporary use, they are of such a character that they can be easily fixed and removed. A *lewis* [129] is usually employed for this work. It consists of three pieces of iron, each having an eye at the upper end; of these the centre one is uniform in width but the outer ones are each wedge-shaped on one side, so that when placed together they form a broad wedge of iron. The lewis is completed by an iron loop and an iron pin. For use a wedge-shaped mortise, suited in size to the lewis to be used, is cut in the stone as nearly as possible over its centre of gravity, so that when lifted it will not tend to turn over. The two side pieces of the lewis are placed in the mortice one after the other; the straight centre piece, whose use is to separate them and force them against the sides of the mortice, is then inserted. When in position, the loop handle is adjusted and the pin passed through the eyes of the loop; the stone may then be lifted by means of the lewis, and swung into position. The lewis is easily removed by taking out the pin, and if the irons have become wedged against the side, a blow with a hammer will drive the wedges downwards sufficiently to loosen them.

A somewhat simpler form consists of a conical plug with an eye; but as this is in a single piece, the mouth of the conical mortise must be wide enough to admit the wider part of the plug, and, to make it of any use for lifting, a second parallel-sided iron plug must be inserted between the lewis and the stone to keep it pressed against the side of the mortise. This form is used for hard stones only, and principally for granite.

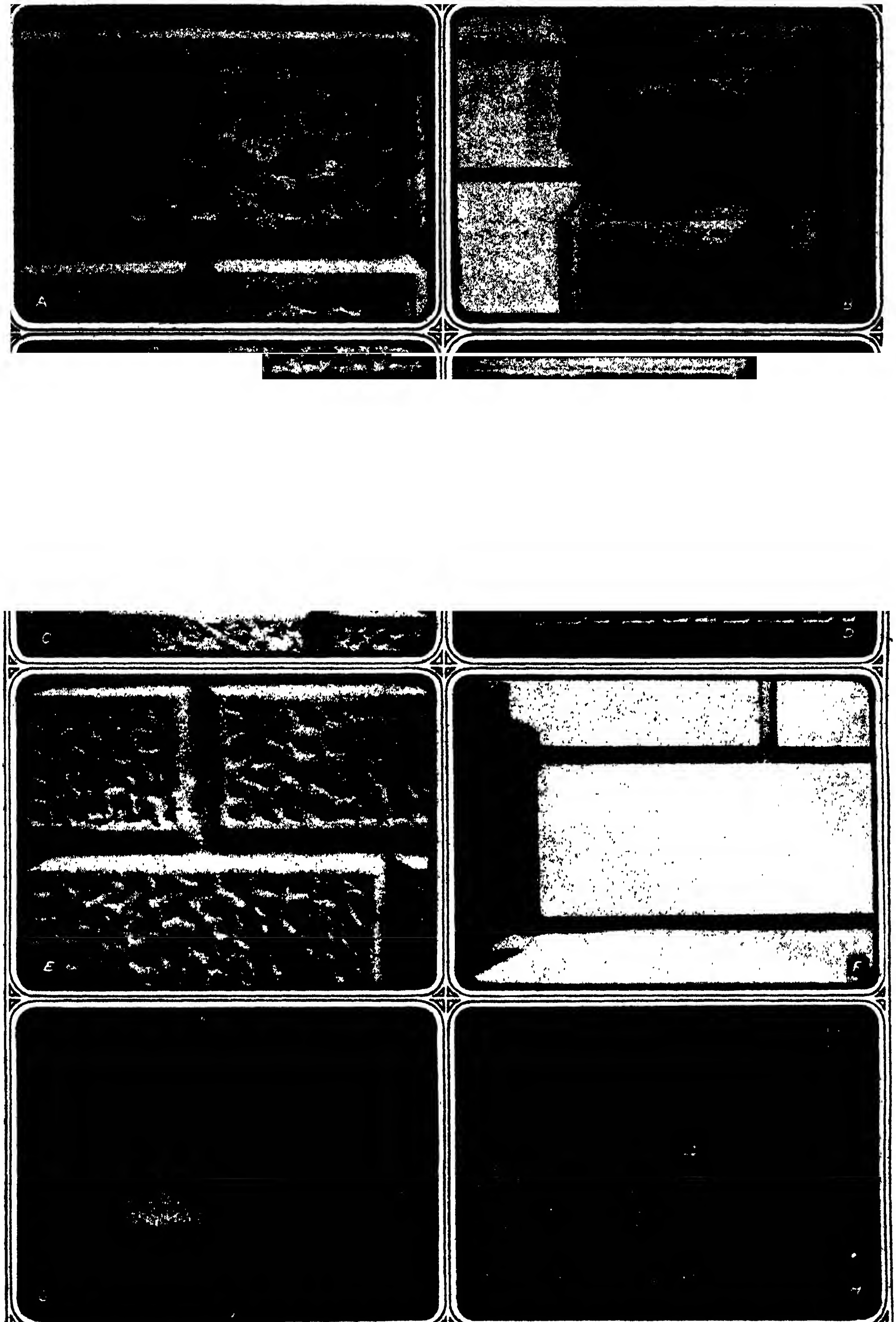
A pair of *chain lewises* [129] is sometimes used. These consist of two curved irons, which fit into a wedge-shaped mortise; the heads are curved outwards and fitted with rings through which a chain is passed: when the chain is strained tight for lifting, it tends to draw the heads together and thrust out the lower ends tight against the sides of the mortise, giving a firm grip.

Nippers [129] are also formed with curved irons furnished with steel-pointed claws. They are held together by a pivot, and the upper ends have rings. For lifting, a chain is passed through these rings, and when strained, draws them together so that the claws securely grip the sides of the block. It is of great importance that these be adjusted, with reference to the centre of gravity, so that the stone, when lifted, will not revolve, but keep its bed even. When used for setting stones, this must be particularly attended to.

The Process of Dressing Stones. In working up stones for their position in the building, which is termed *dressing the stones,* a rough block or a piece cut from such a block is selected; it should be large enough to contain the required finished block, and to allow of its being cut from it without unnecessary labour and waste. The first process for all ordinary work is to reduce one face to an absolutely true plane; if the block has a sawn face this may probably be done without much labour, but if the surface is rough as received from the quarry it will be more troublesome.

Two straightedges are required of uniform width and four small blocks of hard wood of uniform height. Near each corner of the block a small piece of stone is worked off to form a bed in which these blocks are placed one at each corner, and each of the two straightedges is supported on two blocks on opposite sides; by *boning* them—that is, placing the eye level with the nearest rod and looking across to the further one. It is then seen at once whether the upper surfaces coincide exactly. If they do, the four prepared surfaces are in one plane; if they do not, one or more of them must be further sunk until this result is secured. Care must be taken to see that no part of the irregular stone face between the angles is below the level of this plane.

When the four angles are levelled, *drafts* are worked across the face of the stone along the edges connecting them; these drafts are narrow strips or bands which are worked off before the general surface is dealt with, and they are carefully worked so as to lie exactly in the same plane as the angle pieces. Afterwards, additional diagonal drafts are worked across at short intervals, and frequently tested with the straightedge during the operation. The surface is afterwards cleaned off and reduced to the general level, and then forms a perfectly true plane surface if the work has been properly executed. From this bed one end or side is squared so as to form a right angle with the plane originally prepared, and the other sides are in turn worked so as to be perpendicular to the upper face and at right angles with each other. The last face, which formed the bottom of the stone, if it is required to be wrought, is marked all round with a gauge to give the required thickness, and is then dressed down,



132. VARIOUS FACINGS USED IN MASONRY

A. Rusticated masonry from Telephone House, London *B.* Rock-faced masonry from Bank of England (Law Courts Branch) *C.* Rusticated pier from Somerset House *D.* Vermiculated quoin from the Temple *E.* Vermiculated masonry from Savoy Street *F.* Rubbed masonry from City of London School *G.* Fine-tooled masonry from J. J. Astor's offices *H.* Coarse-tooled masonry from Waterloo Bridge stairs

but is sometimes left rough and undressed if it is to be built into a wall.

Various Styles of Finishing Surfaces. The manner in which the stone faces are finished varies with the nature of the stone and the effect that it is desired to produce. It must be borne in mind that the appearance of the stonework—what is often described as the *texture*—will vary according to the tool used, and the manner in which it is used. With the harder forms of freestone, unless exposed to exceptionally severe conditions, the surface of the stone will remain just as the mason leaves it for many years, and under favourable conditions for many centuries; and in such cases it is worth while to take extra trouble to produce such a surface as will enhance the appearance of the masonry. With soft freestones the surface cannot be relied on as being so permanent, and the marks of the tool will in time disappear, so that it is not usual to leave them visible on such stones, but they are worked with a drag or comb to a smooth face.

Raised Surfaces. The surface of the hard freestones may be varied (1) by using different tools; (2) by using the same tool differently. For large blocks of stone forming a wall face it is not always necessary to reduce the exposed face to a perfectly smooth and level plane except for a short width all round the edge of the stone, which must be dealt with so as to ensure the true setting of the stones, but the centre part of the face may be left rough, not perhaps just as quarried, but merely roughly shaped with a spalling hammer. Such a treatment is described as *rock faced* [B, 132], while the edge or margin which is worked off to the regular plane is known as a *drafted margin*, and is usually from 1 in. to 2 in. in width, depending on the size of the stone.

Another surface, somewhat less rough and suitable for stones of smaller size and in a smaller building, is known as *punched rock-face*. This is formed with the punch, which is driven in a nearly vertical direction, forming small pits between which the stone is split off in flakes.

The point is used for forming a series of depressions between rougher ridges running diagonally across the stone, and this is termed a *broached face*. Where a bold surface effect is wanted, and a somewhat more formal treatment is required than is given by the rock face, the surface is carefully wrought into a series of ridges and sinkings known as *rusticated work* [A and C, 132], or where they are so arranged as to take somewhat the character of the convolutions of a worm they are termed *vermiculated* [D and E, 132]. In all these various styles of finish in which the centre of the stone is raised a drafted margin is employed.

133. CITY OF LONDON SCHOOL
Example of masonry with rubbed face

Flat Surfaces. Stones that are to be finished without any raised face are nevertheless susceptible of different treatment, but in this case it is due to the different disposition of the tool marks. For such work the *broad tool* is often used, or, at least, a wide boaster, and a good deal of skill is required to produce regular and even tooling. The surface may have the tool marks disposed irregularly over its surface, and is then termed *random tooled* [G, 132], or they may be disposed in regular broad lines one above another, forming successive bands right across the stone and entirely covering its surface, and to this class of work the term *tooled* [H, 132] is applied. The tooling may also be worked so that the strokes are diagonal in lines, and it is then termed *stroked* or *droved* work. In each of these styles the tooling may be continued up to the edges of the stone, or a margin may be tooled all round the stone, forming a kind of central panel. The marks of the tool form a series of small ridges and furrows on the stone, and these may be made finer or coarser according to the class of material and the kind of effect desired. The above work is suitable for external and internal masonry, but the bolder kinds are reserved usually for external work. In positions in which stone is subject to any direct wearing action which would tend to obliterate the tooling, it is useless to employ it, and for such positions as the exposed faces of landings, steps, and thresholds, the surface is usually rubbed after having been brought to a fairly fine face. The rubbing is performed by another piece of freestone used with sand and water, and the face is rendered quite smooth and all tool marks are obliterated. Such stones are described as having a *rubbed face* [F, 132 and 133]. Soft freestones are finished with the drag, which is worked all over the surface, and reduces it to a level and smooth face but without any distinct tool marks; such work is described as having a *dragged face*.

Continued

A SHORT DICTIONARY OF MASONRY AND SLATING

For many general terms see also Dictionaries of BUILDING CONSTRUCTION (page 310) and of BRICKWORK (page 1954)

ALABASTER—A very fine grained form of gypsum.
Apex Stone—The stone forming the top of a gable.
Architrave—In columnar architecture, the stone resting directly on the columns.
Architrave Moulding—A group of mouldings running round an opening.
Artificial Stone—A material manufactured in imitation of stone.
Ashlar—Masonry formed with carefully squared stones in regular courses.
Axe—A heavy tool with a chisel edge used in dressing granites.

a slate, the upper surface when laid.
ack-jointed—A rebate formed on to receive the

short stone shaft turned

with
base and capping.
bench on which a mason

vault,

ing stone in a Portland quarry.
Bath Stone—An oolitic limestone largely quarried near Bath.
Battlements—An indented parapet, finishing a wall.
Bed of a Slate—The under-surface as laid.
Bevel—A tool of brass or iron for

k-in-course—A class of masonry with squared stones.
A course of squared above a cornice.
—A chisel whose edge is from

asonry sur-
ing, cutting
roughly to the intended

nes which penetrate
of a wall to assist

Boss—A projecting mass of stone at of moulded ribs,

Broached Face—One worked with diagonal furrows produced with a point.
Broad Tool—A chisel about 4 in. wide, used for tooling.

CAEN STONE—A soft, white limestone imported from Normandy.
Cantilever—A shaped bracket of stone or slate, of which one end is pinned into a wall.
Carrara—A white Italian marble, used largely for chimney-pieces.
Centre Nailed—In slating, fixing slates near their centre.
Chalk—A calcareous earth sometimes hard enough for building.
Chilmark—An oolitic limestone found near Tisbury.
Chisel—A tool with a cutting edge from ¼ to 1½ in. broad.
Chiselled Work—A wrought surface left from the chisel.
Claw Tool—One like a broad chisel with teeth on the edge.
Cleavage Plane—The plane in which some rocks readily split.
Countess Slates—Those which measure 20 by 10 in.
Coursed—Built in regular horizontal courses.
Cover Tile—A rounded tile covering the joint of two adjacent tiles in some forms of tiling.

Crab—A form of crane used to lift large stones.
Cramp—A metal bar let into two adjacent stones as a tie.
Crenelations—The openings in an embattled parapet.
Cross-cut Saw—A two-handled, toothed steel saw for cutting soft stones.
Cross Vault—One produced by the intersection of two barrel vaults.
Curb Stones—Those forming a continuous edge, as in a path.
Curtail Step—The lowest step in a flight, with the outer end formed as a scroll.

DIAGONAL RIB—One running between the opposite angles of a rectangular vault.
Diaper-work—The enrichment of a stone surface with small geometrical designs.
Dolomite—A magnesian limestone in which carbonate of magnesia and carbonate of lime occur in equal proportions.
Dovetail Cramps—Slate cramps cut to form a double dovetail.
Dowel—A pin of slate or metal to of timber

Draft—A strip or margin on either side of an arris wrought with a chisel.
Drafted Margin—A draft running round all edges of a stone.
Drag—A broad steel plate with a serrated edge for dressing soft stones.
Dragged Face—A stone face finished with a drag.

fixing.
Drip Stone—A projecting moulding above an opening to throw off water.
Droved Ashlar—A Scotch term for chiselled or random-tooled ashlar.
Duchess Slates—Those measuring 24 by 12 in.

EAVES COURSE—The lowest course of slates or tiles in a roof with eaves.
Embattled—A wall finished at the top with embrasures.
Embrasure—A notch or sinking in the upper edge of a parapet.

FACE—Of a stone, the side exposed when built into a wall.
Face Mould—A pattern giving the form to which a stone face is to be worked.
Feathers—Thin concave pieces of iron used in splitting granite.
Flags—Thin stones used for paving, often laminated.
Flint—Stones formed of nearly pure silica found with chalk.
Flyers—Steps in a flight, the fronts of which are parallel.
Formeret—The vaulting rib that forms the junction between a vault and the arcade wall.
Frame-saw—A large, toothless saw for cutting harder freestones.
Freestone—Any stone capable of being readily tooled.

GALLETING—Inserting small stone chips in broad mortar joints.
Gargoyle—A stone water-shoot, often grotesquely carved.
Gauge—In slated and tiled roofs, the distance from the tail of one slate or tile to the tail of the next.
Geometrical Stair—One formed with radiating steps round an open well-hole.
Glass Tiles—Pieces of glass cut to the form of tiles and laid in a tiled roof to give light.
Granite—An igneous rock composed of quartz mica and felspar.

Grit Stone—A hard sandstone.
Groin—The line formed by the intersection of two vaults at an angle.
Groining Rib—A rib built to support the groin of a vault.
Gypsum—A soft stone formed of hydrated sulphate of lime.

HAMMER DRESSED—Stone that has been dressed with a hammer only.
Heading—The vertical sides of a stone at right angles to the face.
Heading Joint—The joint between the headings of adjacent stones.
Head Nailing—Fixing a slate with nails close to the head.
Head of a Slate—The upper end as laid.
Hearting—The centre part of a wall between the facings.
Hewn Stone—Stone brought to a required form with hammer and chisel.
Hip-tile—A tile of special form used in tiled roofs to form hips.
Hood Moulding—Another term for a dripstone.
Hookstone—A stone which receives the hook or pin of a strap hinge, and is built into a wall or pier.

INTERMEDIATE RIB—One occurring between a diagonal rib and the transverse or wall rib, and springing from the shaft.
Irregular Coursed Rubble—Rubble in which the horizontal beds are not continuous.

used in
ening.
Joggle—A joint formed with an indentation in the surface of one stone to receive a projection on the adjoining stone.
Jumper—A long iron chisel used for drilling holes.

KENTISH RAG—A form of compact limestone suitable for rubble work.
Kerb—See *curb*.
Key Course—The course of stones forming the crown of a barrel vault.
Key Stone—The stone forming the crown of an arch.
Knapping—The process of flints for walling.
Kneeler—A square seating worked in certain coping-stones in a raking parapet.

LABEL OR LABEL MOULDING—See *dripstone*.
Lacing Courses—Bonding courses of ashlar or brick used in flint walls.
Ladies—Slates measuring 16 by 8 in.
Laminated—Stones which readily split into thin layers.
Lap—The extent to which the head of one slate or tile is covered by the tail of the next course but one above it.
Lewis—A form of iron wedge used for lifting heavy stones.
Lierne Rib—A short cross-rib in a vault that does not spring from a shaft.
Limestone—A general term for all stones of which the principal ingredient is carbonate of lime.
Lintol—A horizontal beam of stone or timber, spanning a door or window opening.

MALLET—A tool with circular head of hard wood for striking cutting tools.
Marble—Carbonate of lime in a crystalline or semi-crystalline form.
Margin—That part of the back of a tile that is exposed when laid.

Masonry—The art of forming and uniting stones to form walls and other structures.
Millstone Grit—A very hard, coarse-grained sandstone.
Monolith—A column or other object formed of a single stone.
Mortice—A sinking cut into a stone.

NATURAL BED—The bed on which a stone was originally deposited in formation.
Newel—A vertical column or pier placed at the angles of a flight of stairs or forming the centre of a spiral stair.
Nippers—A pair of iron claws used for lifting stones.
Nosing—The salient edge of a step, often moulded.

OBELISK—A lofty pillar, square on plan, and diminished towards the top.
Onyx—A term applied to an Oriental alabaster, and to certain marbles found in Algeria and Mexico.
Oolites—The class of limestone formed of minute egg-shaped grains.
Open Newel Stair—One in which the steps are built in at one end, and with no central newel.

PANTILE—One that is not flat but undulating in form.
Parian—A white marble, from the Greek island of Paros.
Patent Axe—An axe formed of several strips of steel, each with a cutting edge.
Pentelic Marble—A white marble, from Mount Pentelicus in Greece.
Pick—A heavy hammer-shaped tool with sharp ends.
Pick-Faced—Work that has been dressed with a pick, or in freestones with a point.
Pillar—A disengaged stone column generally irregular in plan.
Pinnacle—A pointed termination at the top of a buttress or gable.
Pitching—The process of knocking off rough lumps from a block.
Pitchings—Cubes of granite used for paving.
Pitching Tool—Resembles a chisel, but has a bevelled not a cutting edge.
Plain Ashlar—Ashlar the surface of which has been rubbed.
Plugs—Circular conical pieces of iron used with *feathers* in splitting granite; also pieces of wood or lead let into stones for fixing joinery.
Point—A tool with a narrow chisel edge used with a mallet.
Polishing—A process by which a smooth, glossy surface is given to marbles and granites.
Polygonal Rubble—A carefully formed rubble wall without horizontal beds.
Porphyry—An igneous rock of a reddish colour found in Egypt; generally any rock containing embedded crystals distinct from the main mass.
Portland Stone—An oolitic limestone largely quarried in the island of Portland.
Princesses—Slates measuring 24 by 14 in.
Punch—A tool with a narrow chisel edge used with a hammer.

found

Y—A place from which any stone or slate is obtained.
Quarry Sap—The moisture contained in all stones when quarried.
Quarry-worked—Stone that is dressed at the quarry before delivery.
Queens—Slates measuring 36 by 24 in.

RADIATING JOINTS—Those which radiate from a common centre.

Raglet—A groove cut in stonework to receive lead flashings.
Random Rubble—Rubble masonry in which all joints are irregular.
Random Tooled—Masonry in which the tool-marks are irregular in direction.
Rib—A narrow arch below the surface of a vault to support or enrich it.
Ridge-rib—A rib forming a division at the top of adjacent severeys.
Ridge-tile—A tile of special form for covering the ridge of a roof.
Ripper—A tool used for cutting old nails in repairing slate roofs.
Riser—The vertical front of a step.
Roach—The topmost bed of Portland stone available for building.
Roestone—An oolite, the grains of which are of large size.
Rouge Royal—A reddish veined marble, found in France and Belgium.
Rubbed Work—Plain work, the face rubbed down with freestone.
Rubble—Masonry built of rough stone not reduced to a uniform size or carefully wrought.
Rusticated Masonry — Masonry formed of large stones, the face left rough and with a drafted margin.
Rustic Quoin—Quoins the edges of which are bevelled so that the face stands in front of the wall face.

SADDLEBACK COPING—A coping, the top of which slopes in two directions.
Saddleback Joint—A joint used on weathered surfaces to prevent water from soaking in.
Sandstones—Those composed of grains of sand cemented together.
Sarking Felt—Felt used for lining roofs.
Scabbling—Consists in shaping blocks roughly by knocking off irregularities.
Scabbling Hammer—A very heavy hammer used in granite work.
Scribe—Incising the outline of a moulding with a sharp pointer.
Sedimentary Rock—Stone that has been deposited by the action of water.
Self-faced—A term applied to slate slabs when used just as split.
Serpentine—A soft, mottled, richly-coloured stone, used for decorative work.
Setting—The process of fixing dressed stones in their position.
Setts or Paving Setts—See *pitchings*.
Severey—A compartment of a vault between two main ribs.
Sicilian Marble — A whitish-veined marble, largely used for lavatory tops.
Sienna Marble—A rich clouded yellow marble found near Sienna, Italy.
Slate—A sedimentary rock that has been subjected to great pressure.
Slating Battens—Strips of deal sawn to sizes, to which slates are nailed.
Slurry—A mixture of stone dust and lime.
Snecks—Small squared stones used in rubble work to square up irregular courses.
Spalling Hammer—A hammer weighing about 12 lb., used for knocking rough lumps.

the enclosing lines may be straight or curved.
Spire—The termination of a tower, circular or polygonal, the sides converging to an apex.
Splitters—Small chisels formed with a cup-shaped or hollow end.
Spurstone—A stone, usually of granite, used to protect the lower part of gateways.
Square—A right-angled tool made of iron plate.

Stairs—A series of stone blocks so disposed as to give access from one level to another.
Step—One of the blocks forming stairs.
Stone-cutting—The art of hewing or dressing stones to definite shapes.
Stone Tiles—Large slabs of laminated stones used as a roofing material.
Stooling—The base to receive a jamb or mullion worked in the same block as the sill.
Straight-edge—A rule whose two edges are parallel.
Stratified—A stone that has been deposited in regular layers or strata.
Stroked Work—Finished like tooling, but tool-marks are formed diagonally
Summerstone—The lowest stone at the side of a gable which includes the first portion of the coping.

TABLED JOINT—One in which part of the bed of one stone is let into the next course.
Tacks—Strips of metal used to support new slates in repairing a roof.
Tail—The lower end of a slate or tile.
Templet—A block of stone placed in a wall or pier to receive the end of a girder or beam. [*See also* page 311.]
Threshold—A block of stone forming a doorsill flush with the floor.
Throat—A hollow groove under a projecting sill or coping.
Through-stone—A bond stone passing through the whole thickness of a wall.
Tierceron—See *intermediate rib*.
Tilting Fillet—A strip of wood used to raise the bottom or one edge of slates or tiles.
Tisbury Stone—See *chilmark*.
Tooling—Finishing a stone surface so that regular tool-marks are displayed.
Torching—Pointing applied to the underside of slate or tile roofs.
Tracery—The disposition of bars in an arch or window so as to form geometrical designs.
Trammel—A rod, or arrangement of rods, for describing large curves.
Transverse Rib—The one in a vault that runs at right angles to its main axis.
Tread—The upper surface of a step.

UNCOURSED RUBBLE—See *random rubble*.

VALLEY TILE—A tile of special form used in tiled roofs to form valleys.
Venetian Tile—A tile with raised edges used with cover tiles.
Verde-Antique—A mottled green serpentine much used for paving.
Vermiculated Work — A form of rusticated work disposed in lines like the undulations of a worm.
Viscountess Slates—Those which measure 18 by 10 in.

WALL RIB—See *formeret*.
Water Table—A projection with a weathered surface, used in buttresses to throw off water.
Weather Tiling—Vertical tiling hung on walls to protect them.
Whitbed—The bed in a Portland stone

slating.
Winder—A step in which the tread is wider at one end than the other.

YORK STONE—A hard, laminated sandstone, suited for steps, pavings, and templates, largely quarried in Yorkshire.

ZAX—The tool with which slates are trimmed.

OPEN-AIR WORKING

The Tools Used in Rope and Rotary Boring and their Operation. Different Systems of Open-Air Work. Instances of its Prosecution on a Large Scale

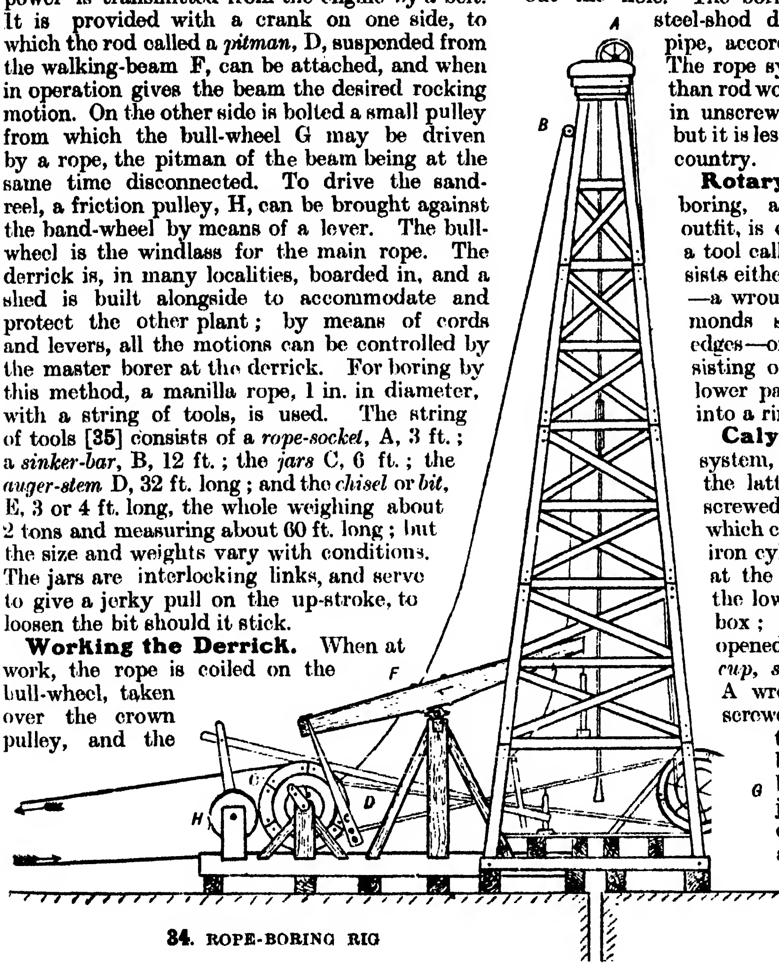
Continued from page 2671

By D. A. LOUIS

PERCUSSIVE boring with rope is frequently known as the Chinese method, from its early use in China, but the method to which we shall now refer is the system perfected in America for the purpose of obtaining petroleum and natural gas. The plant required includes a *derrick*, an *engine*, a *band-wheel*, a *walking-beam*, a *bull-wheel*, and a *sand-pump reel*.

The derrick [84] is a frame-work tower, pyramidal in form, frequently 72 ft. high, tapering from 20 ft. sq. at the base to 3 ft. sq. at the top. It is provided with a pulley, A, for the main rope, and a second pulley, B, for the sand-pump rope. The engine is generally an ordinary reciprocating oil, gas, or steam engine. The band-wheel is a wooden pulley, C, to which power is transmitted from the engine by a belt. It is provided with a crank on one side, to which the rod called a *pitman*, D, suspended from the walking-beam F, can be attached, and when in operation gives the beam the desired rocking motion. On the other side is bolted a small pulley from which the bull-wheel G may be driven by a rope, the pitman of the beam being at the same time disconnected. To drive the sand-reel, a friction pulley, H, can be brought against the band-wheel by means of a lever. The bull-wheel is the windlass for the main rope. The derrick is, in many localities, boarded in, and a shed is built alongside to accommodate and protect the other plant; by means of cords and levers, all the motions can be controlled by the master borer at the derrick. For boring by this method, a manilla rope, 1 in. in diameter, with a string of tools, is used. The string of tools [35] consists of a *rope-socket*, A, 3 ft.; a *sinker-bar*, B, 12 ft.; the *jars* C, 6 ft.; the *auger-stem* D, 32 ft. long; and the *chisel* or *bit*, E, 3 or 4 ft. long, the whole weighing about 2 tons and measuring about 60 ft. long; but the size and weights vary with conditions. The jars are interlocking links, and serve to give a jerky pull on the up-stroke, to loosen the bit should it stick.

Working the Derrick. When at work, the rope is coiled on the bull-wheel, taken over the crown pulley, and the string of tools screwed together in the usual way and in the above order; the whole is run down into the hole, the rope being clamped by means of the *temper-screw* F, above which is the *stirrup* G [35], which is suspended vertically from the walking beam. The beam is set rocking and at each down-stroke the bit strikes a blow, and, as usual, a turn is given between each blow by means of a lever at the temper-screw, and in this way the drilling advances. When the screw in the stirrup reaches its limit, the walking-beam is stopped, the temper-screw released, the stirrup-screw run up, a fresh length of rope let out, the temper-screw reclamped, and the boring continued. When necessary, the string of tools is wound up and the sludger, or sand pump, sent down to clean out the hole. The boring is started with a steel-shod drive pipe or a guide pipe, according to circumstances. The rope system is far more rapid than rod work, as the time occupied in unscrewing the rods is saved, but it is less reliable in treacherous country.



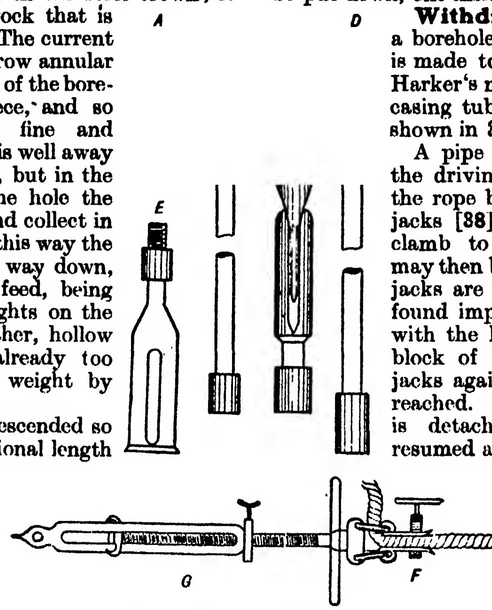
84. ROPE-BORING RIG

Rotary Boring. Rotary boring, as in the prospecting outfit, is conducted by means of a tool called a *crown*, which consists either of the *diamond crown* —a wrought-iron ring with diamonds set round the lower edges—or of *steel crown*, consisting of a steel cylinder, the lower part of which is formed into a ring of sharp teeth.

Calyx System. In this system, the crown A [36] is of the latter description, and is screwed into the boring piece, which consists of two wrought-iron cylinders, C, D, separated at the middle by a block, E; the lower cylinder is the core-box; the upper, which is opened at the top, the *chip cup*, *sediment tube*, or *calyx*. A wrought-iron pipe, B, is screwed into and passes through the dividing block at its centre, and by means of screw joints, lengths of pipes can be added so that a line of pipe continues to the surface. The diameter of the cutting ring of the crown is larger than the

diameter of the boring piece. The operation consists in giving the crown a rotary motion, which is conveyed to it through the line of pipe from an engine and gearing at the surface. The crown works on the rock below it, chipping or wearing away the material in its path. When the rock is very hard, chilled shot and a special crown are used. Water is forced down the tube B during the operation to keep the crown cool, and the spaces between the teeth in the steel crown; it washes away the loose rock that is chipped or worn away. The current is very strong in the narrow annular channel between the sides of the borehole and the boring piece, and so all the fragments—both fine and coarse—are carried up this well away from the scene of action, but in the unobstructed part of the hole the coarser particles settle and collect in the settling tube C. In this way the crown steadily works its way down, its rate of descent, or feed, being regulated by putting weights on the top of the pipes, or rather, hollow rods; or if they be already too heavy, by reducing the weight by balancing.

When the crown has descended so far as to require an additional length of pipe, this is screwed in at the surface, and operations restarted. When, however, it is desired to withdraw the core F and empty the sediment tube, the whole appliance has to be drawn to the surface, the pipes being unscrewed in lengths as long as possible, to save time and trouble in screwing and unscrewing. Inside the crown there is a wedge-ring, which allows the core to pass upwards during the progress of the boring, but which jams when the crown is pulled up, and the core is not only broken off, but also retained. At the surface the core is taken out, marked, its depth recorded, and it is set aside for examination. Whichever method of boring is adopted, the operation is continued until definite information is obtained, unless some other cause necessitates a cessation of work.



35. ROPE-BORING TOOLS

Accidents. Borings, percussive or rotary, rarely proceed without accidents, and consequently the fishing and other implements [23, page 2666] are only too frequently brought into use.

Lining Boreholes. Boreholes generally require lining, which is done by driving down wrought-iron pipes, screwed together. The modes of making the joints are shown in 37. In most cases, they can be withdrawn when the borehole is no longer of use. In the case of water, mineral water, boric acid, natural gas, brine, petroleum, workings, the borehole assumes a more or less permanent character, as it is the only passage by which the mineral wealth can be brought to the surface, then the lining has to be very carefully looked to.

If the borehole require to be lined to any considerable depth, it may be found necessary after a certain depth to reduce the size of the casing tube, and a second or more lines of tubing may be put down, one inside the others.

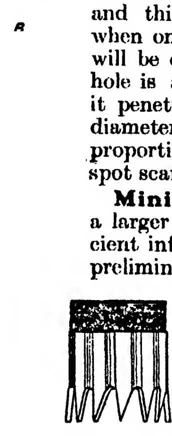
Withdrawing Tubes. When a borehole is abandoned an attempt is made to recover the tubing, and Harker's method of withdrawing the casing tubes from the boreholes is shown in 38.

A pipe clamb is attached below the driving cap and is slung from the rope by means of a chain. The jacks [38] are placed beneath the clamb to start the tubes, which may then be drawn up. If, when the jacks are out to full extent, it be found impossible to raise the tubes with the hoisting machine, another block of timber is added and the jacks again applied until a joint is reached. The top length of tubes is detached, and the operations resumed as at the commencement.

Boring on a still larger scale will receive attention later.

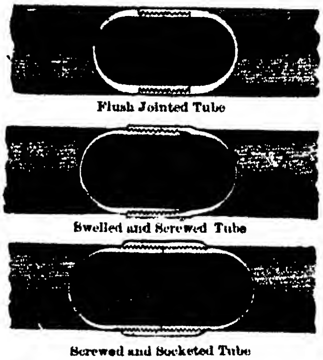
The value of boreholes for ascertaining the position, dip, strike, thickness, extent, regularity, or otherwise, of a deposit, is incontestable, and in the cases of gaseous, liquid, and many bedded deposits, they may give a very good indication of the quality of the mineral. But too much importance must not be placed on the indication of quality given by boreholes in irregular mineralised deposits, such as veins, for instance, and this precaution is particularly necessary when only one borehole has been driven. This will be obvious when it is realised that a borehole is a mere speck compared with the area it penetrates; for instance, a hole a foot in diameter in the area of an acre could only be proportionately represented on this page by a spot scarcely visible without a magnifying glass.

Mining or Quarrying. Operations on a larger scale should be started only when sufficient information has been accumulated by the preliminary investigations fully to justify them. Boreholes, trenching, costeaning, drivages, and other exploratory operations enable the mining engineer to form a judgment of the quality and quantity of useful mineral that may be expected from any deposit that has been examined; and from the price the mineral would fetch the approximate value for the deposit may be calculated. The supply of



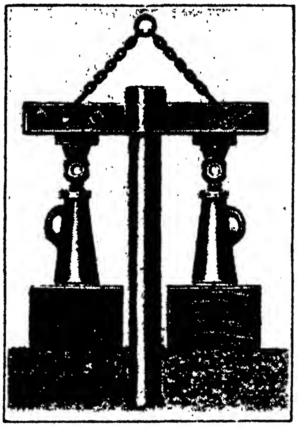
36. BORING WITH STEEL CROWN

fuel, of timber for mining purposes, of water for domestic, milling, and power requirements, suitability for electrical transmission of power, and transport facilities are all points that have to be taken into account. Then the price of labour and appliances for getting the mineral out of the ground enters into the question. The appliances and operations may be comparatively insignificant in the case of a quarry, but become a very considerable factor in the case of a mine. In addition to this initial cost, mining operations will entail a constant and heavy expenditure. Again, useful minerals are frequently associated with useless minerals, which cannot be separated in the mining operations; and they not only add to the expense of mining itself, but lead to an additional expenditure in plant and labour for effecting the subsequent separation. Hence, it is very important to include in an estimation of value not only the value as ascertained by testing, but also the expenditure that will be necessary to render the paying mineral marketable. For instance, to start a coal-mine 1,000 ft. deep on a basis that will prove remunerative demands an expenditure of £250,000 or more, and one of the deeper-level gold-mines in the Transvaal would require an outlay of over a million sterling to install on a paying basis.



37. BOREHOLE CASING TUBES

Methods of Working. The stage has now been reached when it is necessary to decide in what manner any deposit that has proved of sufficient value shall be worked. The most simple and economical method consistent with efficiency in extraction and the safety of the workers will naturally commend itself. In some cases there is no choice of method, as for instance, in brine wells and oil wells, which are worked by means of boreholes. Deposits beneath water, also, must be worked either by dredging or by diving or diverting a river, unless the water can be drained off or otherwise disposed of; of course, when a sufficient covering or roof intervenes between the water and the useful deposit, the latter can be worked by ordinary mining methods. Round the coast of Great Britain there are many instances of this being done.


38. EXTRACTING BOREHOLE LINING

The ordinary mining and quarrying operations resolve themselves into two classes: *open air works* and *underground works*. The former have the advantage over the latter, that the whole of the useful mineral can be removed without timbering, without artificial ventilation, without fear of explosions, and without expense for lighting—at least, while there is daylight—and with easier supervision; but they are more liable to interruption from vagaries of climate than underground works.

Open Air Works. Gravel, chalk, clay, etc., pits, some ore workings, quarries, open-cast mining, streaming and beach washing, hydraulicing, dredging, are examples of open air work.

Pits, Quarries, and Open-cast Mining. These terms are applied to mineral workings that are conducted in the open air. Pits particularly refer to operations in soft and loose material of a non-metallic character. Quarries refer to workings in hard, non-metallic material; and open-cast mining to workings for material to be used for the production of metal. In the last-mentioned case the material is not always soft but sometimes is very hard. Then the simple pickaxe and shovel have to give way to drilling and blasting.

Shovel and Barrow Work. The simplest mode of extracting useful mineral from the ground is by shovelling it into a barrow or waggon and wheeling it away; sometimes a pick, sometimes a crowbar, may also be called into requisition, but yet the process remains quite simple. Gravel pits, sand pits, chalk pits, brick pits, are worked in this way, and are familiar to most people. There are few localities where works of this sort may not be encountered, and in many places round London—near Erith, for instance—very extensive excavations of this description may be seen. The material is easily broken away, and the chief precaution that is necessary is to be careful as the excavation deepens that too much is not cut away from the lower part to as to endanger the workers from a fall of the material above.

Some ore deposits are worked in an exactly similar way. At Almondsbury, in Gloucestershire, and in carboniferous limestone country, small quantities of lead ore are dug out of the ground, filled directly into carts to be taken away. At Frodingham in Lincolnshire, and elsewhere in that part of the country, beds of iron ore of Lower Lias age extend just below the surface over great areas; for working them a long stretch is exposed by means of a cutting forming a face which may be a mile long, a tramway or even a full gauge railway is laid down and trucks are brought right up to the face to be filled. The surface soil is first removed and put on one side to be restored to the surface after the iron ore is taken away, which is speedily done by picks and shovels, and as the face gets worked back in this way,

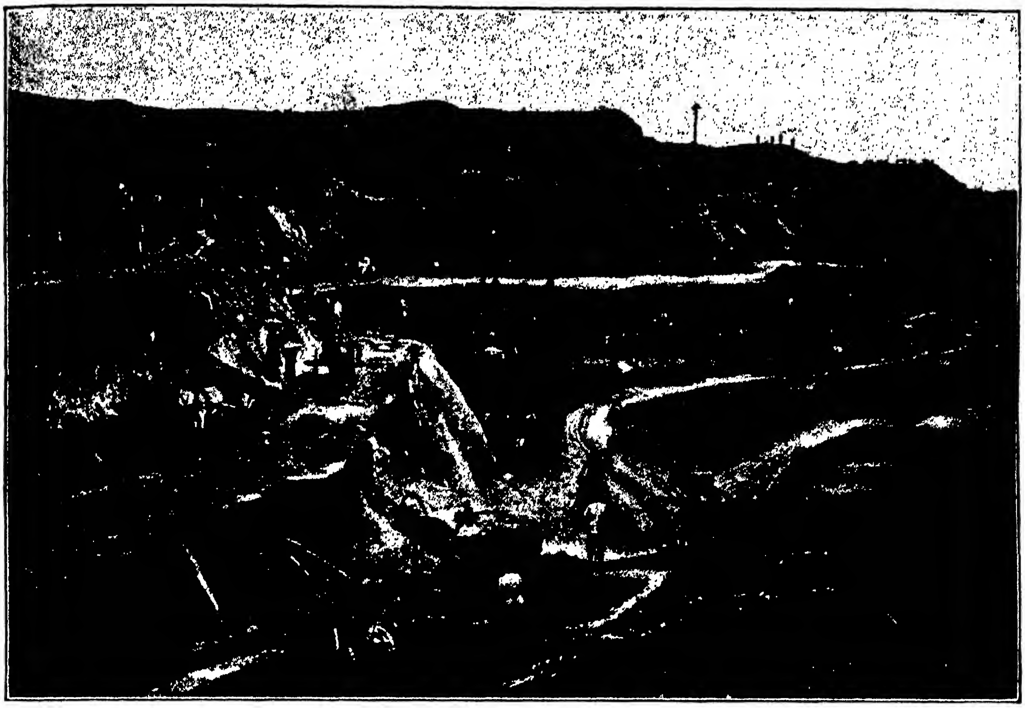
the rails are advanced to keep up to it. This practice is not restricted to this country, for in the Ural Mountain district of Russia the writer has inspected gold-bearing gravel deposits worked in an exactly similar manner, while in America enormous iron ore deposits of this class are being worked in this way, the extraction being expedited by the use of immense steam shovels.

Digging Deeper. To work deposits deeper or harder than those just alluded to—for instance, those exceeding 30 or 40 feet in depth or covered by a more considerable over-burden — the simple methods just described have to be amplified. Then, to meet the increased thickness it may no longer be desirable to work from one floor at one great wall, but to provide intermediate floors or benches and to remove deposit in stages, while to deal with the increased over-burden, provision has to be made for its removal and disposal. An example of this condition is found also in the Lincolnshire ore field in the vicinity of the city of Lincoln. In this locality [39] the Northampton sands ironstone is overlaid by more than 30 ft. of Oolitic limestone, which has to be removed in stages, and is thrown on the worked-out ground ; the ironstone beneath is then dug out in the usual way and loaded into little tram waggons.

39. GREETWELL IRONSTONE MINES
Photo by Geologists' Association

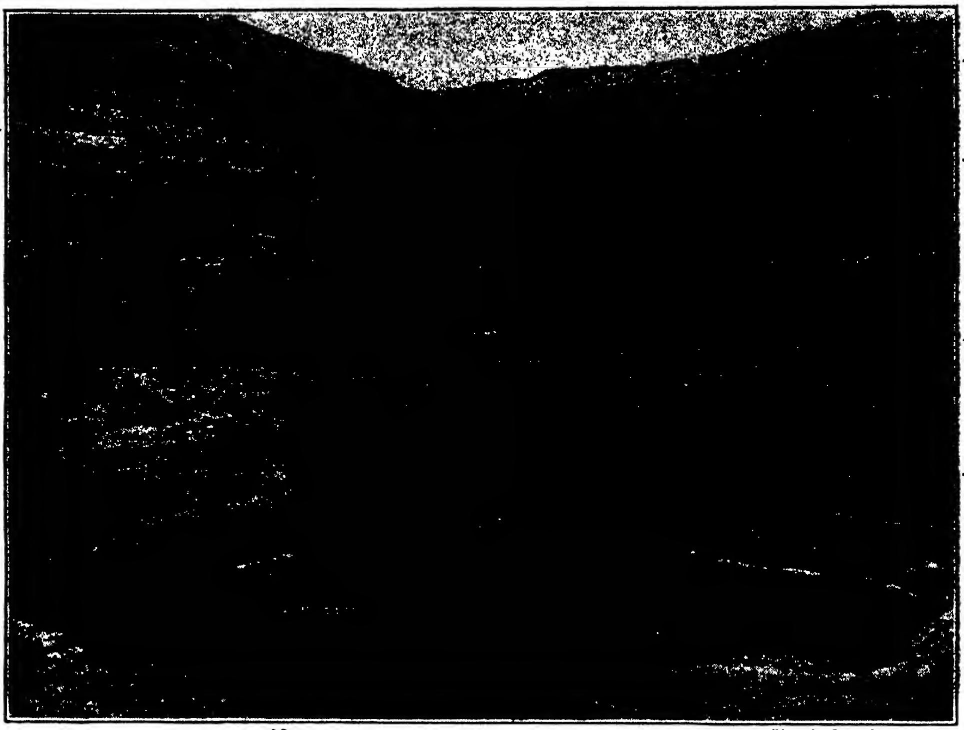
As an example of working a hard and comparatively narrow deposit, opencast to some depth, one of the iron mines at Gellivare, in Lapland, is illustrated [40]. In this case the deposit of ore has been entered from the outer end and gradually worked away, the difficulties of height being overcome by the use of long ladders and temporary timber staging.

40. IRON ORE WORKING AT GELLIVARE, IN LAPLAND



41. AN OPEN-CAST WORKING IN THE URALS

42. TERRACED WORKINGS, ERZBERG, STYRIA. BLASTING IN PROGRESS



43. PLASTER QUARRY, ROMAINVILLE, PARIS *Photo by Leon Janet, Paris*

Terraced Workings. Deposits of still greater thickness are worked away in series of terraces or *benches* to provide several working faces to minimise the danger from falls and to facilitate the operations of extraction. Such floors are from 15 ft. to 30 ft. or even of greater depth, according to circumstances, and each upper working is kept sufficiently well ahead of the next lower working to leave plenty of room on the floor for men to excavate and load, and for the accommodation of the trams, carts, or barrows.

There are many workings of this kind on the Continent and elsewhere—the famous Rio Tinto mines for instance; and the writer recalls the 50 terraces of Eisenerz, in Styria, towering up above the valley; also the great open-cast workings at Gellivare, in Lapland, and various mines in the north-east of Russia in Europe. In the latter locality the excavations have all the appearance of some colossal amphitheatre with miles of roads running right round at levels one above the other, but each connected by inclines with the one above and the one below, and where hundreds of little two-wheeled carts drawn by little ponies are constantly moving, some taking stuff away from the working, some returning empty to be charged again, many driven by women and girls; while hundreds of men and boys are engaged in digging out the ore and loading the carts. In activity the scene may veritably be compared to the appearance of a hive of bees. Fig. 41 shows one of the smaller open-cast workings in the Urals.

Fig. 42 shows part of the workings on the famous Erzberg, in Styria. This is a mighty mass of iron ore computed at some 200,000,000 tons, and is the largest deposit in the Austrian Empire. The terraces vary in height from 30 ft. to 50 ft., the whole extending some 2,000 ft. in height. The lowest terrace is over 2,700 ft. above sea-level and the highest about 4,700 ft. The ore is won by drilling and blasting and is conveyed away by a system of inclines and tram lines over 60 miles in extent. The yearly output is 1,000,000 tons, and in the summer months 4,000 men are employed.

Quarrying Plaster of Paris. The plaster of Paris quarries in the neighbourhood of the French capital furnish a very good example of this sort of working in soft material. The beds are of Oligocene and Eocene age, and are open to a depth of 228 ft. at Park Quarry, Romainville. The 60 ft. above A [43], and the 46 ft. A to B are in the Oligocene, and consist of limestone, green clays, and white and blue marls. Then follow 54 ft. of gypsum, also containing strontium, to C, 14 ft. of marls, to D, and another 25 ft. of gypsum. The remaining beds, with 10 ft. of gypsum and the rest marls, are below the level of the view. Every bed is utilised for some purpose or another; the gypsum is used for making the plaster of Paris. The beds are worked in a succession of terraces, but when any of the lower beds are required in advance of the upper ones, underground work is resorted to. The striking points about these quarries are the absence of machinery and the perfect tidiness that prevails.

Continued

LEATHER MANUFACTURE

Antiquity and History of Leather Manufacture. The Raw Material and its Treatment. Science in the Production of Leather

By W. S. MURPHY

WHEN the City shoeblack says, "Clean your boots, sir?" he too modestly describes his art. The cleaning is a preliminary process only; his main duty is to make the boots shine by the application of a paste or black oil, which, besides adding to the fine appearance of our pedal extremities, preserves the leather. Colliers, ploughmen, and other workers who labour amid changing conditions of heat and cold, wet and drought—the prudent among them, at least—grease their boots. Prepared fat acts as a preservative of hides; this is the primary basis of the leather industry.

Mythological Origin. We do not know who began it. The following account, given in the form of a myth, is probably as true as any. When, in the depths of the primeval forest, the human hunters slew their rival beasts, it occurred to one of them to deck himself with the skins in triumph. The fashion caught on, and all the hunters adopted the practice. But the trophies had a mysterious way of falling to pieces, breeding ugly vermin, and giving off offensive smell, turning the glory of the conquerors into vexation and shame. It seems that for a time the wearing of skins ceased to be considered good form, but that some of the more notable chiefs invented for themselves fine-sounding names, descriptive of their deeds, and so began heroic poetry. After a time, however, a man was born who, having a fine sense of the futility of words, sought out a means of preserving the trophies, and discovered that the fat of the animal itself would preserve the skin.

What is Leather? All leather is preserved skin. The skin of an animal is part of the living organism. When the condition we name death supervenes, the organism falls to pieces, changes its form and character one way or another, and assumes new shapes and modes of action. In general, it putrefies. The cause of putrefaction is twofold. Within the living organism are small animals termed bacteria or bacilli. So long as the main stream of life is maintained, these minute creatures are kept subordinate to the general life; but when the vital energy declines, they begin to assert themselves, and grow, feed, and multiply, on the neighbouring tissues. Hence spring the curious growths of putrefaction. The second cause is fermentation, which gives rise to the offensive effluvia. By the activity of the bacilli, certain gases in the hide composition are liberated, and these are eagerly sucked up by the watery vapours in the air. A humid atmosphere stimulates putrefaction. If, therefore, by some means the bacilli could be killed, and the hides made impervious to water, putrefaction would be prevented. Fat first, and smoke afterwards, were found to answer the purpose.

Primitive Leather. Fatted hides and smoked skins were the earliest forms of leather. Both preservatives were adopted early. In that way were made the shields of Boadicea and her followers when they vainly strove to turn the tide of the Roman invasion; and the targe of Roderick Dhu—

> "Whose brazen studs and tough bull hide,
> Had death so often dashed aside."

The preservation of skins, however, was only the first step towards leather manufacture. Fat is not a perfect cure, and smoke may be defeated by dampness. Some other agent had to be found, and it was discovered in the acid secretions of certain trees and plants.

Tanning is no modern industry. More than four thousand years ago there were tanneries in Egypt, and the trade seems to have been of such importance that the figures of leather-dressers at work were sculptured in marble on a monument, the fragments of which are to be seen in the Berlin Museum. How many people have seen the dainty shoe of some Egyptian beauty, who lived three thousand years ago, in the British museum? The tanner figures in history at most unexpected places. Peter lodged with "one Simon, a tanner, at Joppa." William the Conqueror was the son of a tanner's daughter, and when he besieged Alençon, the townsmen hung raw hides on the city walls, crying, "Work for the tanner," afterwards to pay a fearful price for their mockery. And there were tanneries at Meudon, during the French Revolution, the products of which were the tanned skins of men.

The British Leather Trade. For several centuries the growth of the British leather trade was slow and quiet. Under the Saxon kings, one of England's chief exports was raw hide, the merchants going as far as Constantinople. Early in the fourteenth century, however, the trade had so far grown that it took part in breaking down the monopoly of the merchant guilds, and formed the Skinners' Company in 1327. In 1449, the Edinburgh Company of Cordiners was formed; and in 1586, the tanners of that city formed a separate corporation, named the Skinners' Company. These corporations were not strong enough, however, to prevent Parliament from laying the leather trades under very sad and hampering burdens. Up till 1830 the leather trade was under the supervision of the Excise Department, the tax being at times as high as 3d. per pound of leather.

With such restrictive conditions, no trade could flourish, and the real progress of the industry dates from the removal of the imposts. M'Culloch, in his "Statistical Account of the British Empire," estimated that, in 1837, the total production of leather of all kinds in Great Britain amounted in value to about five millions sterling. The present import of raw hides alone amounts annually to over two millions in value.

The Object of Tanning Leather. The aim of the leather manufacturer is to render the hides or skins of animals imputrescent, pliable, capable of resisting climatic change, strain, wear and tear, to the highest degree possible. As we shall see, he employs various agents for his purposes; but the main processes are *tanning* and *currying*.

Three classes of hides come to the ordinary tanning establishment—dried and salted hides from foreign countries, and fresh hides from home. The dried and salted hides are treated to bring them back, as nearly as possible, to the fresh state, and fresh hides are washed free from dirt and blood. The first manufacturing process is depilation, or unhairing, the object of which is to clear off the hair and outer skin, or epidermis. This is done by a method called sweating, or by soaking the hides in pits of lime water till the hair is loosened, when it is cleared off by a blunt knife. The under surface of the inner skin, which carries a layer of fatty substance, is cut away in a similar manner. By processes varying in degree of elaboration and effectiveness according to the class of hide, the pelts are cleared of lime.

Next comes the tanning. There are several methods of tanning, and modern ingenuity tends to multiply the number. The object of all, however, is to introduce a preservative agent into the very substance of the hide so as to destroy the putrefactive powers. This is the root principle of oil tanning, alum tanning or tawing, chrome or mineral tanning, and oak-bark tanning. Formerly, the tanners of this country were confined to oak-bark as a tanning material. Recent chemical discoveries have vastly increased the sources of tanning agents.

Having tanned the hides, or skins, the leather manufacturer's business is to render his product as flexible and useful as he can. Here, again, the methods vary; but in general it may be said that the introduction of unguents, or oils or fats, is the main object of currying or dressing. By these processes the fibres of the leather are coated with a lubricant, which is also preservative and of waterproofing quality.

Varieties of Hides. Technically, hides are the skins of oxen, buffaloes, horses, and all the larger animals; skins are derived from sheep, goats, calves, dogs, rabbits, kids, and the smaller quadrupeds. The demands of other industrials and modern fashion have impelled the leather manufacturer to go far afield for his raw materials. Cutlers ask for thick leathers to clothe their buffing wheels, and the hippopotamus is hunted and stripped of his thick hide; purse manufacturers and upholsterers seek novelty to tickle the fancies of customers, and the lion, the crocodile, and the alligator are killed and skinned to meet the demand; belt-users ask ever heavier and stronger belts, and the wilds of the world are ransacked for animals with skins equal to the purpose.

The hide-store of a large tannery is frequently a zoological museum of skins; hides of tiger, lion, elk, bison, bear, alligator, rhinoceros, and zebra lie beside those of bullocks, horses, and other tame cattle. They are collected from the ends of the earth to be preserved from inevitable decay, made useful and ornamental, and the art of the tanner does it.

The Structure of the Hide. We wonder sometimes if many of the myriad wearers of boots ever know the hidden nature of the leather they grind underfoot. Leather is not the obvious material most people imagine that it is. We look, most of us, upon the hairy coat of a bullock or a cow and imagine that we see the thing of which leather is made. It is a gross error, and does serious injustice to the leather manufacturer. Leather is to the hide what the kernel is to the nut. The thing we see is a mere husk without the vital elements that give leather its toughness and durability.

The skins of all animals consist of two sets of layers—the outer, or epidermis; the inner, called the derma, cutis, corium, or skin proper. Scientific expositors have a curious habit of using long words and involved sentences which, though easy to the students of science, appear mysterious to the non-technical inquirer. We do not propose to explore the mysteries of cellular structure or discuss the physiological and chemical characteristics of animal tissues. Our duty is to explain, as definitely and clearly as possible, the structure of the hides with which the leather manufacturer has to deal.

The Epidermis. Look, first, at the epidermis. On the outer surface we find a layer of scales, perforated with minute holes and hairs. This is the scarf-skin, and from it grow hair-sheaths, nails, horns, and hoofs. Underneath are the sweat glands and hair bulbs, embedded in a mucous layer composed of living cells, deriving their nutriment from the blood-vessels in the true skin through a gauzy membrane called the *hyaline* or glassy layer. Clear away the epidermis, and you take off sweat glands, fat glands, and hair, and leave bare the true skin.

The True Skin. The skin is far more compact in structure than the epidermis, and consists mainly of interlacing bundles of white fibres, fine threads woven together and cemented by a gluey substance, now recognised as being itself tissue finely organised. Beneath the skin lies the fatty tissue that connects it with the flesh, and this is the white surface seen on the inner sides of all fresh skins.

It must be clearly understood that these layers are not separate, like sheets of paper, but organically connected, palpitating with one life. The hair, for example, though embedded in the epidermis, has its roots in the true skin. The

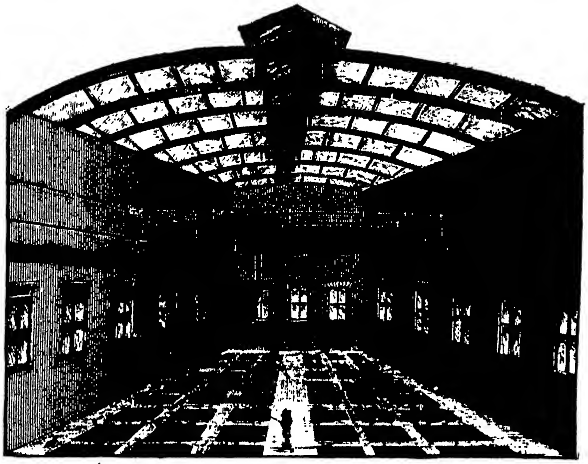
question for the tanner, therefore, is how to get the kernel or true skin from between the organic layers on both sides of it. It may be said that the problem was solved ages ago; but that is only partially true. Industrial operations are now carried on under conditions from which the old rule-of-thumb workers would have shrunk aghast. Every hide brought into the tanyard must be accounted for and made into leather.

Rule of Thumb. That was not so in the old days. If one hide, or a batch of hides, turned out badly, the occurrence was referred to misfortune rather than fault. Time and material were both cheap, and leather manufacture was a handicraft dependent partly on the skill of the craftsman and partly on the fluctuations of fortune. Such uncertainty is intolerable to the modern industrial worker; to hold his own in the market he needs to eliminate chance and accident from his operations and subject to his purposes the materials and instruments with which he labours.

Soaking and Softening. Hides and skins come to the tannery, as already stated, in three different conditions—salted, dried, or fresh. Fresh hides require to be washed clean from blood, lymph, and other matters. This should be done as quickly as possible in clean, soft water, strengthened by a percentage of carbolic acid. Slovenly soaking, though it may seem to matter little at the moment, and may sometimes show no bad effects, often produces results which render all subsequent processes worse than useless. Curious superstitions grow up in trades, and one of these is the notion among tanners that a dirty soak helps the tanning. It may be that occasionally the soak becomes chemically identical with a weak tanning liquor; but even an accident so economical does not always prove happy. The safe rule is to let every process stand by itself and do its own work and no more. Clean hides are all that the soak is designed to produce, and the leather manufacturer will be wise to be content therewith.

Salted Hides. Foreign hides must be salted or dried to preserve them while passing from the distant scene of slaughter to the tannery. Salted hides have a wrinkled appearance and harsh texture, of which the tanner must get rid before starting to work. If not taken out at this stage, the wrinkles will remain till the end.

A very simple and sensible method of ridding salted hides from salt and the effects of salt is to suspend them in a water pit, the water of which is changed every day. This seems so obvious, it looks like redundancy to enlarge upon it. But circumstances frequently hinder men from acting simply. When water is at a premium and land is dear, when the Rivers Pollution officers are on the alert and means of purification find no room in the tannery, it is natural that other methods of taking the salt out of hides should be attempted, and carried through. Several chemicals have been used for the purpose, but as these are also used in the treatment of dried hides, their action will be described under that head. When water is scarce and rapid work is desired, a wash-wheel may be used. A wash-wheel is any kind of perforated cylinder revolving in water with spokes fixed on a spindle in the centre. The hides are put in the cylinder on the spokes, and as the wheel turns round they are tumbled about freely in the water.



1. TAN PITS, WITH TRAVELLING CRANE
(Joseph Hall & Co., Leeds)

Dried Hides. Dried hides require treatment more drastic. As we saw, rigorous drying is a primitive method of preserving skins, and to undo the work of the driers is sometimes no easy task. The fibres cling, resist water, and obstinately preserve a wrinkled appearance. Moreover, the hides may have been slightly putrefied before drying. Experienced tanners know exactly the various markets whence the hides are supplied and how they have been prepared, and can act accordingly. But suppose that a beginner has to handle a dried hide, or a hide has come from a new source of supply, what then?

The Soak-pit. The prudent way is to proceed step by step. First steep the hide in the ordinary soak-pit [1] in pure water, and see what the effect is in a day. If no appreciable effect be visible, or if putrefaction has set in, a weak solution of caustic soda should be tried. This is generally effective at a strength of one part to a thousand. The caustic soda penetrates the fibres, carrying the water with it, causing the hide to swell out to its natural state. The great merit of this solvent is that it does not harm the fibres of the skin, and acts as an antiseptic. Sodium sulphide has also been used with good effect, but this chemical hinders the succeeding process of unhairing by liming. Caustic soda is said by some authorities to have a similar effect, though in a less degree. But the slight additional expenditure of time

in the lime pits is more than recompensed by the saving of hides and the certainty of results which follow its use.

Chemical Agents. Other chemical soaking solutions have been patented, and all have merits of their own. Each inventor, however, supplies to the purchaser ample directions for the use of his own patent.

If a solution of either caustic soda or sodium sulphide be used, a period of from twenty-four to forty-eight hours will suffice to soften even very stubborn hides. A short soaking in clean water afterwards adds to their freshness. As a rule, the hides are now plump and ready for the unhairing, but some hides are specially difficult to soften. This hardness has to be broken down. Before the age of machinery these obstinate hides were broken over the *beam* with a blunt knife.

Let us explain, for these terms will occur often. The beam is a large block of wood, convex in front, like the trunk of a tree standing endwise on the floor and sloped to an angle. On this the workman lays the hide, and with his blunt knife works the fibres on the beam, loosening them and breaking down the stiffness of the hide. *Breaking over* is the term applied to this action.

"Breaking-over." Breaking-over by hand is very hard work and takes up precious time. Here was an opening for the machine-tool maker, and he was not long in seeing it. Some ingenious individual had seen the fulling stocks working in a textile factory, and decided to utilise them for the benefit of the hide breaker. As we use the fulling stocks for other purposes, a slight description of them may here be given. The stocks are two huge wooden legs with flat heads like mallets. The heads rest on the bottom of a sloping trough, and the feet extend in an angular direction to a mechanical arrangement that lifts and drops the legs alternately. If a hide be laid on the end of the trough, the mallet heads will come down on it with a slanting blow that strikes and drags it at the same time. Properly used, these stocks are very serviceable; but they scarcely suit dry hides and tend rather to weaken the fibres at the very start. Few tanners now break hides in that way, and use either the water-drum or no machinery at all. Probably the chemist has the solution in his hands, and some claim that he has already obviated the need of mechanical breaking. Practical experience alone can guide us in a matter so undetermined. It will be observed at this point, and at many others yet to be noticed, that the leather industry has not been reduced to a series of mechanical operations, and calls for the exercise of intelligence and skill on the part of the workman.

2. UNHAIRING
From a photograph taken at Elswick Leather Works, Newcastle

Unhairing or Depilation. When the hide has been cleaned and softened, it is ready to be freed from the epidermis and hair [2]. If by any means we can at the same time swell and split up the fibres of the skin for the tanner, he will be all the better pleased.

Sweating. In the rude old times, tanners were wont to lay the skins and hides in piles between heaps of manure till they had been thoroughly sweated by the generated heat and the ammonia from the decomposing mass. Later, the dung heap was abandoned and artificial heating resorted to, with the addition of salt to mitigate the effect of the putrefying agents; but even this was abandoned for the sweat-pit, which, besides being more sanitary, had the advantage of being more under control. Sweat-pits are now almost unknown in England, but on the Continent they are still used. Built of solid stone, the walls protected by mounds of earth all round, with lattice floor beneath which steam pipes for heating are set, the sweat-pit is divided into small compartments each capable of hanging fifty hides. The hides are hung up, the heating started, a spraying apparatus for reducing the heat geared to the rafters, and the whole hermetically closed. For a period varying between four and six days the sweating is kept going. Between the heat and the humid air fermentation works on the epidermis, putrefying it. The vapours of ammonia freed by the decaying matters assist in the process, till the hair and epidermis are ready to slough off. Sweating is open to several objections. Even with the most careful watching putrefaction is apt to attack the skin itself, causing weak grain or fibre. The hide becomes flaccid and pale, needing very strong tanning liquor to restore its bloom. For heavy hides and strong sole leather, however, the sweating-pit has not been surpassed, retaining, as it does, all the strength of the skin, part of which is dissolved in the liquid processes of unhairing.

The Lime-pits. In English tanneries almost the sole agent of unhairing is the lime-pit. Sunk into the floor, eleven feet deep, bottomed and lined with pine boards, puddled with stiff clay, and ranged in rows along the tanyard, the pits are filled with lime water. Lime water is composed of lime and water in the proportion of one and a quarter ounce to the cubic foot. As is well known, lime is chalk, or limestone, from which the carbon dioxide has been driven off by burning in a kiln. It comes to the tanyard as lime shell, ready for slaking, or hydrating. This is best accomplished by laying the lime shell in a small tank, wetting it all over, and after it has heated and crumbled, adding enough water to make it a fine paste. When a lime-pit

has to be filled, reduce the required quantity of paste to a milky liquid in a tub, about four ounces to the cubic foot of water, fill the pit, and pour in the lime. The water will keep in solution the quantity of lime it can hold and let the rest fall to the bottom. Now put in the hides one by one, taking care to let the one be covered with water before laying in the next, and so filling up the pit. When the hides have lain six hours, haul them out with the long hooks, plunge up the lime from the bottom, and set the hides again. This is repeated till the epidermis is thoroughly loosened.

The Effect of Lime. The action of the lime is a solvent one. The scaly cells of the epidermis swell up and soften, the mucous hair tissues dissolve and loosen, and the bulbs break down. On the true skin the effect is wholly different and beneficial. The fibres soften and swell, the skin plumps out, the cement-like fibres dissolving into still finer fibrils, and tend to disappear. This action serves the tanner in two ways. The plumping out of the skin makes it firmer and therefore easier to flesh—that is, free from the inner coating of fatty tissue and the flesh left by the butcher. By splitting up the fibres into individual fibrils, and so exposing a greater surface to the action of the tanning liquors, it also assists in the tanning process. For dressing leathers this is specially of advantage, because these, being tanned in sweet liquors, must have the cement tissues dissolved to attain flexibility. Sole-leather benefits in weight and solidity by the plumping out of the skin, though it is contended that the same result can be better obtained by full-bodied tanning liquors. Lime and fat combine to form a soap, and if allowed full play the lime-pit will reduce the fat of the hide to an insoluble soap, rendering that element innocuous during the rest of the process of manufacture.

3. SHAVING BY HAND
From a photograph taken at Elswick Leather Works, Newcastle

Problems of Lime. There are many questions in regard to lime as a dehairing agent which experts have not yet decided. Such problems as the relative values of old and new lime solutions, how often the pits should be renewed, and the action of the ammonia in old baths, are subjects to be tackled successfully and with understanding only after some practical experience. Different tanyards have various recipes for dehairing liquors, some using pure lime, others adding a small proportion of caustic soda to sharpen the action of the lime. Other chemicals, such as sodium sulphide, red sulphide of arsenic, and alkaline carbonates, are employed as depilatories; but the ordinary working tanyard seldom calls in those refined chemicals. The lime-pit affords a good practical medium, which, with all its drawbacks, has served the leather industry very well.

Unhairing. After the hair has been loosened in the lime-pits, the hides are withdrawn and allowed to drain for about half an hour. Then the workman, taking a blunt knife, two-handled and of convex blade, sits down behind the sloping beam with the hide laid upon it. Leaning over the head of the beam, the workman pushes the hair downward, clearing it off with great facility. Easy as it looks, the novice must not imagine that he can start unhairing right away. There is an art in holding the knife so that it slides over all the inequalities of the hide, clearing the hair off the thin parts as well as the thick, gripping the blunt edge of the knife on to the glassy coating of the true skin. The workman's object is to lay bare that smooth membrane, and the best way to attain an object is to concentrate the attention upon it. Let the knife seek out the hyaline under the epidermis, pushing away all interposing matters, and the hand will instinctively learn to give the force required to the knife.

Fleshing. One side of the skin is cleaned by unhairing [2], but the other has to be treated also, if a leather is to be produced. This side is covered here and there with patches of flesh, and all over by the fatty tissue that lies between skin and flesh. The removal of this is a delicate operation, requiring a sharp knife and fine skill [3]. The fleshing knife is double bladed, one side convex, the other concave, held by two straight handles. As before, the hide is laid on the round beam and the workman runs his knife along the surface, clearing off the matter that obscures the true skin. The right hand grasps the one handle palm downward, to give strength to the stroke, while the other handle lies in the palm of the left hand, directing the sweep and curve. A nice balance is thus secured, and the long blade graduates to the finest line. It is delicate work; the slightest slip, the least forgetfulness of the curve of the beam, and a cut goes deep into the hide. No forcing should be attempted. The tissue should come away easily with the blade, but at points where hard protuberances occur, the blade must be kept flat to the surface of the hide, and cut steadily with the convex edge.

Mechanical Aids. For a long time it was thought impossible to devise a blade which would mechanically clear away the hair and flesh from a hide. The difficulties are real, and many tanners deny that the problem has been solved. Examine a hide closely, and you will see that it is not all of one thickness; it

thickens on the back, thins toward the loins, and shows minute variations all over, callosities developing over some of the bones. A straight blade such as you see in mechanical planers would ruin any hide. Some ingenious inventor, however, devised a spiral knife for the shearing of fine cloth surfaces, and the American machine-maker, whose eyes are on all the earth, seized on the idea and adapted it to the leather industry. Cloth is of uniform thickness and presents an even plane to the horizontal blade. The clever adapter, however, got over the difficulty by making an elastic bed for the hide as it passes under the knife.

A Wide Range of Utility. One of the best of these machines is called the "Vaughan Semi-cylinder." This machine has a roller covered with knives spirally disposed, set above a cylinder resembling a horizontal beam, the surface being only half the circumference. Half the hide is spread on the beam of the cylinder, the remaining half lying in the hollow opening, and the beam brings the hides under the swiftly revolving spiral blades. By the adjustment of the cylinder and the rubber pad on its surface, all the irregularities of the hide are safely negotiated, and the flesh or hair sloughed off. By reversing the cylinder the other half of the hide is brought under the knife.

The adaptability of this form of machine to all sorts of purposes has not been lost sight of. We shall see it again in a British guise when we come to the hide-splitting section. A mere change of knives is sufficient to change the machine described from a fleshing to an unhairing, scudding, or trimming machine. For dressing and fine leathers the machine has come greatly into favour, though the sole-leather manufacturer has not yet seen it to be much to his advantage.

Two reasons are assigned for this. One is, that the labour involved in unhairing is so slight that the hand worker can almost keep time with the machine, and his work is better. The second is, that the pressure of the cutting machine takes the plumpness out of the leather and makes a rough surface with the knife. This conservatism, we are aware, is only a passing phase; but the objections are worthy of note as showing the qualities most desired by good manufacturers of leather. We may take it as certain that those objectors have a keen devotion to their trade and seek excellence of product.

Other Processes. Lime is the almost universal agent for unhairing in British tanneries; it serves on fine and coarse and on light and heavy leathers, for glove, dressing, belting, harness, and sole leathers.

But now the ingredients of the lime-pit separate, under the practice of the division of labour so characteristic of modern industry. Heavy leathers destined for soles of boots and shoes are frequently passed direct to the tan-pits, with, perhaps, a bath of water to wash the rough of the lime away; but the newer and better practice is to subject them to deliming, by means of acid liquors. Harness, strap butt, dressing, calf, and kip leathers are freed by bating from the lime, and otherwise softened; while dog, kid, morocco, and light skins undergo the process called *puering*. Drenching is sometimes made to serve as a substitute for either bating or puering, but, as a rule, it follows as a finishing to both.

Deliming. Pure lime sticks firmly to the hide, and, when combined with certain of the acids used in tanning, forms a hard, gritty substance injurious to the leather. Even water, unless softened, converts the lime into chalk. The simplest method, often adopted, is to suspend the hides in a tank of water, to which small quantities of dilute sulphuric acid are added at intervals, till all the lime has been neutralised. This requires extreme care, as the slightest excess effectually spoils the colour of the leather.

Another handy, and safer, deliming agent for sole and heavy leathers is boracic, or boric, acid. Apply a solution containing 2 per cent. of boric acid to the hides, hang them in the pure water bath, and keep them in motion to prevent spotting. In a short time the lime will have been taken from the hide. Of course, this agent involves risk and trouble, but none of the proposed deliming chemicals seem to be free from one drawback or another. Acetic, formic, and lactic acids have all been used for deliming, and each has its merits. The method of applying these acids differs in no important respects from those already described; but each one has its special dangers to be guarded against.

Sole and heavy belt leathers require to be kept full and plump, and derive no advantage from being made flexible. The harder, stiffer, and heavier a sole leather can be made, the better the shoemaker likes it. Higher, softer, sweeter qualities, however, are possessed by dressing, glove, and kid leathers. The swelling of the water from the lime-pits must be got rid of, and in its place a soft flaccidity imparted.

Continued

3,000 YEARS OF GREEK ART

continued from page 2860

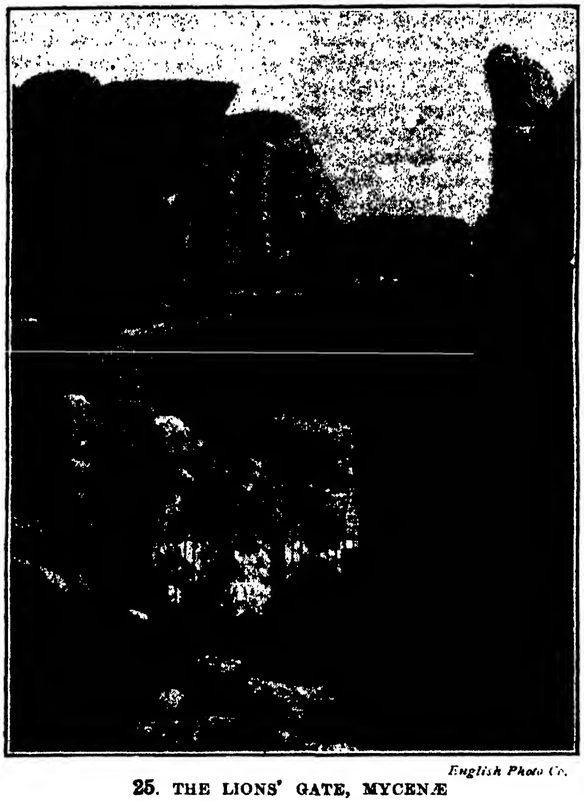
The Greek Ideal. Marvellous Revelations at Crete and Troy. Types of Great Temples. Greek Orders of Architecture

By P. G. KONODY

WE have seen through the rise and decline of Egyptian and Assyrian art that the ideal of the former was hierarchic dignity, and of the latter the expression of strength. The ideal that underlies the art manifestation of ancient Greece is classic beauty. Until about thirty years ago our knowledge of Greek art was practically confined to that great period of unique harmonious development which began about six centuries before the Christian Era. But Schliemann's excavations on the site of ancient Troy, of Mycenæ and Tiryns, disclosed an earlier and more primitive civilisation, which has been given the name of the Mycenæan age; whilst within the last few years the research of Mr. Evans in the island of Crete has resulted in the discovery of the palace of Minos at Knossos, by which the existence of an advanced state of art has been proved as far back as 2,000 years B.C.

The Great Palace of Minos. This gigantic palace of Minos, the labyrinth, the home of the legendary Minotaur, of which five acres have already been brought to light, was built in several storeys, and has a large number of courts, halls, and corridors, in plan not unlike the great palaces of Assyria. The walls were painted with frescoes showing narrow-waisted, long-limbed figures. In the council chamber was a carved gypsum throne, of quasi-Gothic appearance, surrounded by low benches. There were elegant bath-rooms, store-rooms, stone staircases, and "sanitary arrangements ahead of anything that was devised till quite recent times." The wall paintings, some of which are excellently preserved, show processions, bull ring scenes, warriors and ladies seated in their courts, or looking out from their balconies, and also landscapes and seascapes. In sculpture, the Minoan or Cretan period produced some remarkable ivory statuettes, beautifully modelled and of extraordinary freedom of action; and painting and sculpture were combined in the coloured *gesso duro* reliefs with which the walls were frequently decorated.

Legend has associated Dædalus, the first artist craftsman whose name has come down to us, with Minos, the King of Crete, and the examples of craftsmanship that have been found at Knossos prove that great skill and efficiency had been attained at this remote period in the practice of the minor arts, such as goldsmith work, enamelling, cameo cutting, and pottery. Among the objects found at Knossos is a table of gold-plated ivory, set with crystal plaques, which are backed with silver and blue enamel, a real triumph of the craftsman's skill. Everything points to the conclusion that the art of the Minoan period was the culminating point of a lengthy period of artistic development, and evidence has actually been found that the palace of Knossos was built over an earlier royal dwelling, which may date back as far as 3000 B.C.



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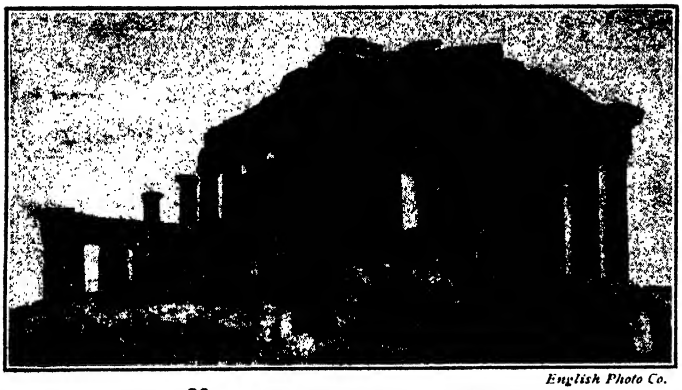
25. THE LIONS' GATE, MYCENÆ

Five Troys Before Homer. On the supposed site of Troy the excavations of Schliemann have brought to the light no less than six cities, one beneath the other. The oldest of these belongs to the Stone Age; among the remains of the second have been found numerous copper objects; while the other four belong to the Bronze Age. The last of all, the Troy of the Iliad, has yielded painted vases,



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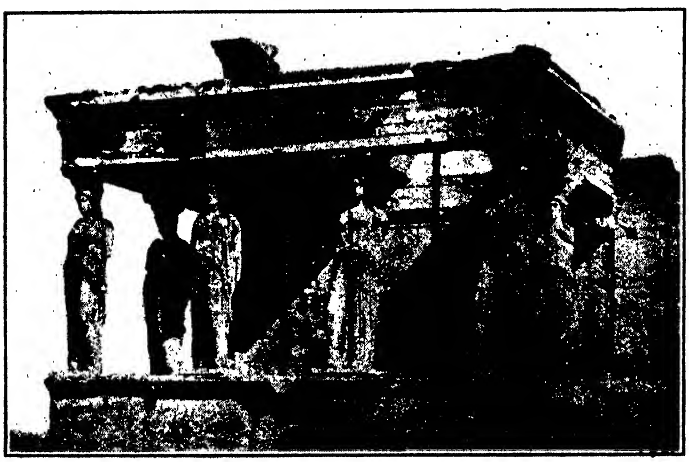
26. THE PARTHENON, ATHENS

bronze tools, and other objects, which have a close resemblance to the objects found on the site of Mycenæ. The whole period has taken its name from this town, and is known as the Mycenæan age, which extends from about 2500 to 1000 B.C. The so-called Cyclopean walls, erected of mighty blocks of stone, piled up without crampons, which have been found in Greece, Southern Italy, and Asia Minor, belong to this epoch. Superposed lintels were employed for the vaulting of entrance gates and passages. Sometimes a heavy beam of stone forms the top of the gate, with lintels above, leaving an open triangular space to relieve the pressure. The famous Gate of Lions at Mycenæ is the most important example of its kind [25]; it has its name from the relief carvings of two lions resting on the beam on each side of a column, with a capital that holds some suggestion of the later Doric order.

Early Greek Art. Metals were extensively used in the Mycenæan age, and numerous gold ornaments, vases of gold and silver, with delicate ornamental designs, thin gold masks, decorated and inlaid bronze daggers, were found in the royal tombs. The ornamentation corresponds partly with that of the ancient Egyptians, and partly, especially in the use of spirals, with that of the Bronze Age in Northern Europe. About 1100 B.C. the Dorian invasion from the north drove the Achæans, or Mycenæans, to the Ægean Islands and to Asia Minor, where they spread their civilisation among the Lydians and Phrygians, whilst Greece itself relapsed into a state of semi-barbarism. Only in the seventh century B.C. the current of culture returned from East to West, and Greece experienced a period of artistic development and grand achievement such as has never since been equalled in the history of the world.

The Greek Orders of Architecture. In architecture, the artistic genius of the Greeks, their sense of beauty and harmony and proportion, found the most perfect expression in the temple buildings. Here, the intention is no longer to impress the mind by sheer bulk and size and mystic symbolism, but by harmonious articulation, perfect balance, and noble simplicity. The elements that give the Greek buildings their character are principally the columns, the entablature, and the pediment——that is, the triangular gable-field under the roof. The essential differences between the three Greek "orders" of architecture—the Doric, the Ionic, and the Corinthian—are illustrated in the diagram on page 2035. They mark the progress from the severe Doric simplicity, where everything is conditioned by strict adherence to the laws of construction, to the more graceful, elegant character of the Ionic style, which in the Corinthian order becomes more playful and free, and less tied to strict rules, for which reason the Corinthian order has been found most adaptable for later developments of architectural style.

In this short survey of the world's art it is impossible to enter into the technical details of the "orders," and for the general reader it will be sufficient to be acquainted with the essential characteristics of the three types of columns. The Doric, with its perfectly plain capital, which can be traced back to an early Egyptian prototype, is short (about five and a half times the length of the diameter at the base) and expressive of strength, the shaft being grooved and tapering upwards. The Ionic column has a capital in the shape of a volute, or scroll-like spiral, and is of slender shape (eight and a half to nine and a half times the diameter), with narrower



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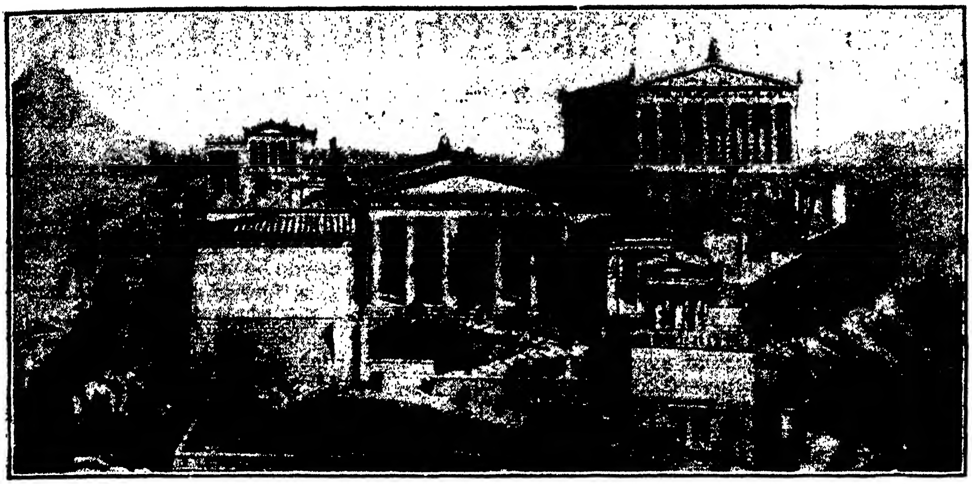
27. THE CARYATIDE PORCH OF THE ERECHTHEION, ATHENS



28. RESTORATION OF THE ACROPOLIS, ATHENS. BY RICHARD BOHN

grooves, which are separated by narrow strips, whilst in the Doric column the grooves meet in a sharp line. This Ionic form was introduced into Greece from Asia Minor. The Corinthian column, finally, has a shaft not unlike the Ionic, and a cup-like capital, formed of acanthus or other leaves.

Types of Temples. The plan of the Greek temples was very simple—of rectangular shape, with a gabled roof, an outer colonnade, a vestibule, and an inner chamber, or cella. According to the arrangement of the exterior columns, the temples belong to one or other of the following classes—the *in antis*, with only two columns at the entrance to the vestibule, and pilasters terminating the side walls; the *prostyle*, with a row of four columns in front; the *amphiprostyle*, arranged like the prostyle, but with a row of four columns added at the back; the *peripteral*, with a row of columns surrounding the walls; the *dipteral*, with two rows of columns all round; and the *pseudo-dipteral*, with only the outer row of surrounding columns (in arrangement like the *peripteral*, but with the columns farther away from the walls). The building material was generally marble, which was decorated in polychrome and with rich sculptural additions, notably in the pediment and on the frieze.

Science in Art. The arch and the vault never occur in the architecture of the classic Greek period, but it is worthy of note that the linear straightness of line in the famous buildings of the Periclean period is more apparent than real. It has, in fact, been proved by recent investigation that all the lines—not only the columns but the very steps leading to the platform on which the temple was erected—were gently, almost imperceptibly, curved, in accordance with certain optic laws which affect the appearance of long-extended straight lines to the human eye. These deviations from the straight were worked out with mathematical precision, and there can be little doubt that they help considerably towards producing that wonderful effect of linear harmony which is produced by all classic Greek buildings.

Of the earlier period, when the Doric order predominated, the most interesting and characteristic remains are to be found, not in Greece, but in Southern Italy and in Sicily, notably at Segesta, Agrigentum, and Pæstum [29]. The Temple of Theseus and the Parthenon in Athens still follow the Doric order, but in elegance of proportions almost vie with Ionic buildings. The Erechtheion [27], the most beautiful building of the Acropolis [28], illustrates the perfect development of the Ionic style. The Corinthian style, finally, tallies with the decline of Greek power, and was generally favoured at the time of Alexander. The Corinthian order played a leading part in Roman architecture and formed the basis for the later composite order.

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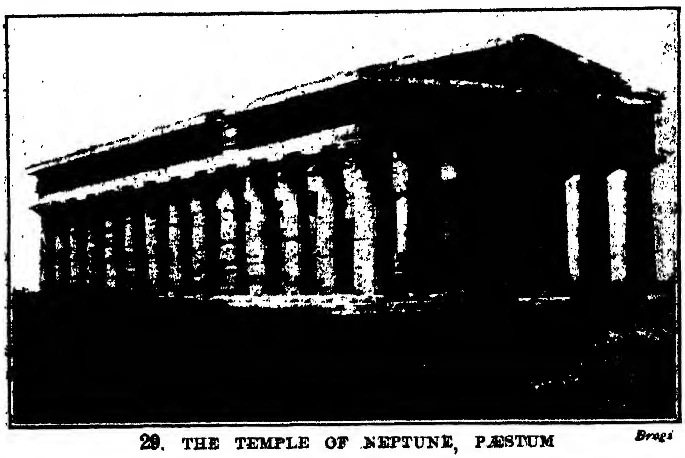

29. THE TEMPLE OF NEPTUNE, PÆSTUM

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Group 17
APPLIED EDUCATION
9
Continued from page 2673

THE FORMATION OF HABITS

The Beginning of Good Habits. Habit Grows from Desire. The Uselessness of Mechanical Repetition. The Moral Tradition Formed by Habit

By HAROLD BEGBIE

IN the eyes of many people the supreme genius of Aristotle lies in his discovery that virtue is habit. The systems of education adopted all over the civilised globe are supposed to be founded on this discovery. Since a virtuous people is the great object of every State, all education is naturally supposed to direct itself to the formation of virtuous habits.

Of late years the cry of the technical educationist has been so loud as to make people think that the sovran goal of education is the Lord Mayor's coach. The State is supposed to have no other object in view in educating its junior members than the manufacture of this human raw material into profitable assets. We are to make ourselves a skilled people, a cunning people, a rich people; our object is to keep our nation the wealthiest and freest in the universe; the ambition of every boy is the Mansion House.

This view will pass away; it is too stupid to survive the struggle for existence to which all human ideas are subjected. The only aim of education, the only possible goal of State training, is character. And when people see that character is not a far-off and, as it were, a spiritual ideal, but a palpable and practical result of habit, they will once more arrange their educational systems to compass this end.

The Striving to Act. But even now much ignorance exists as to the meaning of the term "habit." It is thought that a child can be forced into good habits, as if an elephant could be forced into a rabbit-hole. It is thought that a child with no desire to be clean can be forced into cleanliness by having the habit of washing made compulsory. All this is a heresy. The beginning of education is the will, and until the expression of a human being is towards good the force of habit in good things will avail nothing.

Virtuous habits are formed, say all the ethicists, when natural desires are guided to appropriate acts. "Our souls," says Professor MacCunn, "grow to the modes in which they are exercised. It is by striving to act that our desires come to a fuller, more persistent, and more definite development."

The whole point lies here—in the striving to act. Now, the repetition of an act is a small thing. A servant may polish a door-handle every day for twenty years and at the end of it have no mental appetite for the task. A dipsomaniac may walk past his public-house every day for a month, and yet at the end of this heroic conduct find himself just as desirous of alcohol as he was before. No; the repetition of an act is a secondary thing in character. What is essential, what is the prime agent, is the repetition of the desire. "If the strivings of desire be not induced, the moral habit will not be formed, not even though we could compel the whole physical side of the performance, including the most secret neural and muscular movements."

The Habit of Thinking. It is, in this matter, "the psychical side of outward performances" which counts. We have to create in ourselves the habit of thinking properly. The desire for anything has to be repeated, not so much the performance of it. To take an instance of what we mean: A man struggling to give up the habit of smoking cigarettes has not got to repeat the act of going without a cigarette after such and such a meal, but rather has he to repeat the desire not to wish for the cigarette at that period. A carnival always follows a fast. The last state of the man who denies himself, but leaves his desires unpruned, is worse than the first.

The beginning of this matter is the bending of the inclination. If we want the good habit of rising early, we shall do little good by tumbling out of bed with grumbles and complaints at the summons of a servant. But if we repeat to ourselves the desire that we wish to rise early, and at the servant's summons rise from bed, combating mentally the desire still to lie there, we shall acquire the habit of early rising—that is to say, we shall come to regard early rising with pleasure.

Guidance of the Will. Let it be remembered, above all things, that the fundamental principle in the formation of habits is this guidance and direction of the will. Repetition of an act brings about at last a most useful effect. The act for which we wrestled, and came to grips with all our evil desires, becomes at length an act done without any apparent effort of consciousness. We do not think about it, we merely do it. Without praying, we perform; without effort, we attain. The consciousness which has made so splendid a fight is released, and finds itself free to direct fresh energy into new channels. A virtuous man who has won the habit of virtue in dust and heat will no longer have to lay violent hands upon himself and struggle to prevent himself from vice; he will be virtuous, as it were, unconsciously. But this does not imply that any particular habit can ever become "a mere thing of nerves and muscles," or "wholly a thing of physical automatism." The fact is, says Professor MacCunn, "that the psychical roots of the habit are not cut, only buried. Let but the most automatic of habits be inhibited, perhaps by outward interference, perhaps by inward temptation, the commotion

of the soul that ensues is proof sufficient that the feelings and desires that lie hidden behind are abundantly alive."

Moral Tradition Formed by Habits. The happy phrase has been coined by the same authority that in forming habits the individual is making "a moral tradition" for himself. We build our own psychical constitution, we frame our own psychical magna charta. A habit, repeating itself without conscious effort, establishes in the mind a moral prestige, a spiritual tradition.

This aspect of the subject is important from another point of view. It makes the individual careful in his choice of habits. He is an unwise man who rushes after any particular habit without first inquiring how this habit accords with the general tone of his tradition. Every habit is a stone in the temple of character. We are at work, not on a "crazy" quilt, but on the building of a temple: our plans must be laid before we bring our materials and begin to build. The definite selection of habits tending in one perfectly well-apprehended direction is essential to the man who would build wisely. Every good habit is not necessary to a good character. Unity must be our aim.

There is always a danger that the habit cultivated with such noble effort may in the end produce only a narrow, and perhaps even an injurious, effect. For instance, if the man sensible of cowardice sets about making himself brave by walking through a dark wood at night, he may at the end of three months find himself walking there without even a passing thought of anxiety. But if that same man finds himself in a theatre during a fire it does not follow that he would remain calm and self-possessed. Therefore, in forming a habit the individual is wise who keeps the general idea of that particular virtue in his mind, and seeks variety in his effort to habituate himself in its spirit. It is always the spirit of a habit that should be our chief thought. The habit of early rising, for instance, is an absurd habit to cultivate if we do not feel the energetic and earnest spirit of the act in all our pursuits and occupations. A man wishes to rise early because the morning is the best time for work, and because he wants to push on and use his time to advantage. This is the psychical side of the habit of early rising, and the habit will grow pleasant and easy if the psychical repetition runs through the whole day in all that we set our hands to do. A person most jealous of his time is far more likely to rise easily in the early morning than one who merely rises at the sound of an alarum and during the day is now busy and now idle, now energetic and now a profligate of time.

The Responsibility of Parents. The responsibility of parents in this matter cannot be exaggerated. How many a ruined man looks back over the waste and ravage of his years to the time of his boyhood, exclaiming, "Ah, if my father had only got me into good habits then!" Most parents are content to say to their children, "Pray to God to make you good, and try not to be naughty." They do not teach them that virtue is habit; they do not warn them that vice is habit. Nothing is done to make the child realise the fact of the battle in his own soul. No; he is rather led to fancy that on one side of him is a Good Something called God, and on the other a Bad Something called Satan, and that his conduct depends very much on which of these two Somethings happens to be the stronger at any particular moment. He is not made to feel that he himself is Good and Evil, Heaven and Hell, God and Satan. He is never told that in the physical world there is no forgiveness of sin—never told that the real conflict is with his thoughts and not with his acts. He is never studied by his parents to the end that his natural inclinations may be guided into appropriate acts. No; he grows up unscientifically. His goodness is an accident, his vice is necessitated by his training; he can hardly be called responsible. If a gardener employed with his flowers the methods employed by the majority of parents with their children, the garden would soon revert to the wilderness.

Influence of Social Heredity. It must be remembered, too, that heredity does not play in the formation of character so insistent a part as what has been called "social heredity"—that is, the influence received from our environment. We say of an untidy child of untidy parents, "He inherited his untidiness"; what we should say is, "He learned it from his parents." Not only is the plastic mind of the child influenced by its surroundings, but the mind of the grown man, too. That is why, associating with our fellows, we should be careful to select only those whose influence is appropriate to our end in view. Bad company is bad for us, however good we be; empty and foolish conversation is bad for us, however clever we be. "Go with mean people," says Emerson, "and you think life is mean." No man can altogether escape the influence of his friend, no man can altogether escape the influence of his environment. If we would cultivate habit seriously, and with a unity of character in view, we must take as much pains with the smallest details of our lives as the gardener takes with his flowers or the stock-breeder with his animals.

The repetition of a good thought is far more important than the repetition of a good act. The reading of good literature, a rigorous opposition to trashy literature; the listening to good conversation, a decided refusal to hear stupid conversation; an earnest attention to things that count, and a rigorous neglect of things that do not count; all these are powerful agents in rearing a sane and healthy will. The mind has to be watched for fatigue, and refreshment has to be offered it; but in our selection of recreations we should be as careful to choose wisely as we are in our more serious studies. The will can be educated, and if we begin with that, there will be but little difficulty in acquiring any habit we desire.

Continued

Group 12
MECHANICAL ENGINEERING
20

WORKSHOP PRACTICE continued from page 2700

THE MELTING OF METALS

Various Types of Furnaces: Their Construction and Working. Ladles used in Foundry Practice

By JOSEPH G. HORNER

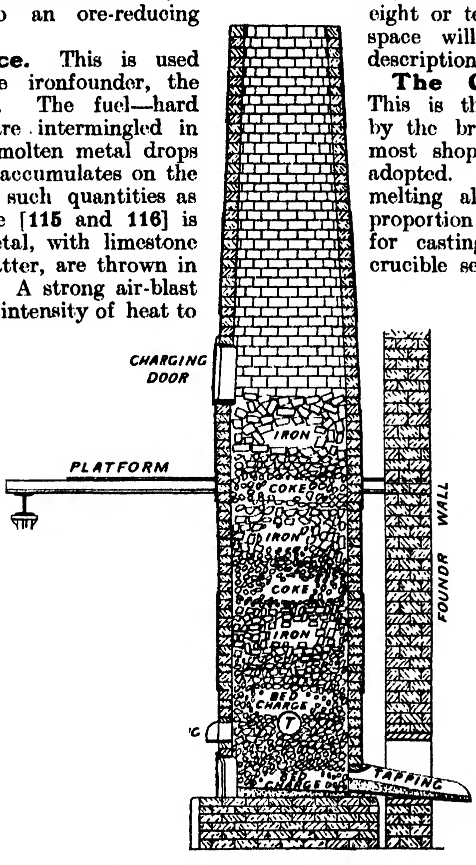
Metal Melting. The melting of metals and alloys for foundry use must not be confounded with the reduction of metals from their ores, with which the founder is not concerned, with the exception of steel made by the open hearth process, which is reduced and poured at once. Even with this, however, scrap steel is generally remelted. Another slight exception occurs in the successful casting of tunnel linings, segments, etc., direct from the blast furnace. But it remains true substantially that all foundry moulds are poured from metal or alloy that has been remelted for the purpose, and frequently more than once. Only by doing so can homogeneity be assured, and grading of different qualities be obtained.

The foundry furnaces used for remelting are divisible under five main heads—the cupola, the crucible, the reverberatory, the converter, and the open hearth, though the last-named, as already remarked, is also an ore-reducing furnace.

The Cupola Furnace. This is used almost exclusively by the ironfounder, the Bessemer cupola excepted. The fuel—hard coke—and pig or scrap are intermingled in successive layers, and the molten metal drops down through the fuel and accumulates on the bed, whence it is tapped in such quantities as are required. The furnace [**115** and **116**] is tall, and the coke and metal, with limestone flux for removing earthy matter, are thrown in through the charging door. A strong air-blast is necessary to produce the intensity of heat to melt the iron. There are different ways of directing this into the furnace. Sometimes it is done by encircling the zone of greatest fusion with a belt, through and from which the blast is distributed through a number of tuyere holes, as in **116**, and this is the better plan. The other is to have two or three bent tuyere pipes arranged equidistantly around the zone, as in **115**, T being one of the tuyere holes. The metal is either tapped directly into a ladle for pouring, or into an intermediate receiver as in **116**. Different grades of metal can be melted at the same time by taking advantage of the separation effected by the alternate layers of coke and iron charged.

Economy in Working. Economy in the consumption of coke used in melting is ensured by the observance of a number of conditions. A short melting is inevitably wasteful, hence a blow of from four to six hours is better than one of two or three hours. In many foundries the cupolas are melting from soon after breakfast up till five or six o'clock. Large cupolas and large volumes of metal are better than the opposite conditions. Good coke is most important; so is an ample volume of blast. Other conditions are a good height of furnace, a deep bed-charge, careful charging, frequent slagging, and melting hot.

The furnace is built of sheet iron lined with firebrick, and daubed with sand around the lower areas. One of the best modern cupolas is the Thwaites, illustrated in **116**. There are eight or ten successful types, but space will not permit of their description.



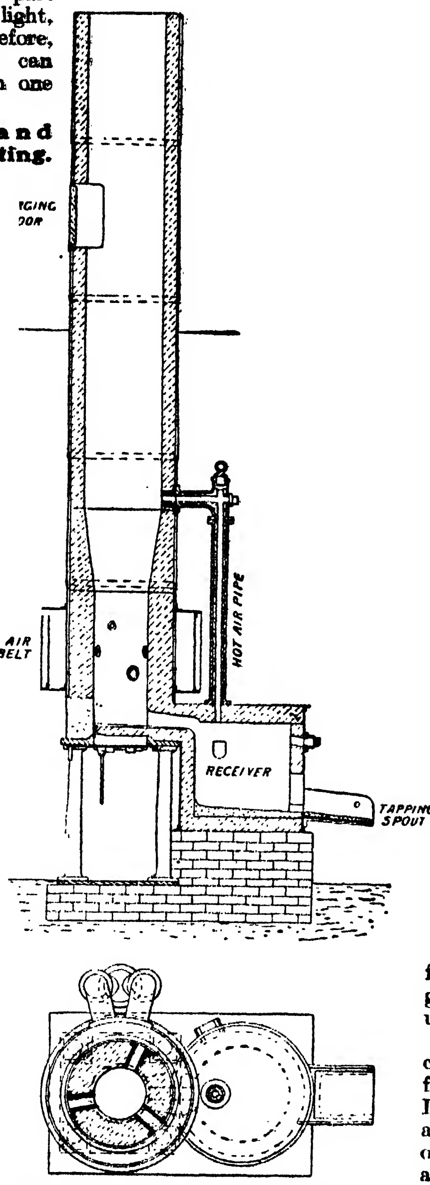
115. COMMON CUPOLA FURNACE

The Crucible Furnace. This is the furnace mostly used by the brassfounder—in fact, in most shops it is the only type adopted. It is also used for melting aluminium and a large proportion of the steel employed for casting. Although a single crucible seldom holds more than a hundredweight of alloy, and must carry rather less than that, yet castings of almost any dimensions are made from them by pouring the contents of a number of crucibles into the mould. This has never been done anywhere on so large a scale as at Krupp's, at Essen, where for many years nothing but crucibles were used for casting the biggest guns. The story has often been told of the hundreds of crucibles of metal all in readiness for the word of command, when they were poured out by the men with military precision. But in England the converter or open-hearth furnace

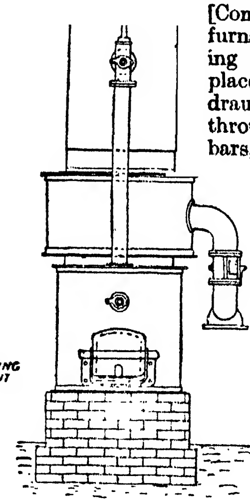
is used for heavy casts in steel, and the reverberatory furnace for those in brass and bronze alloys.

In most brass foundries a battery of furnaces is built [117], numbering from three or four to a dozen, and it is not infrequent for the contents of several to be requisitioned for one cast. But for the most part brasswork is light, and often, therefore, several moulds can be poured from one crucible.

Cupola and Crucible Melting. The reasons why iron is melted in a cupola, in contact with the fuel; and brass alloys, aluminium, and steel in crucibles, are as follows: Iron is much cheaper than the copper alloys and steel, and therefore a little waste is not of much importance. It also generally required in larger quantities. But the principal reason is that iron is not injured by contact with the fuel, while the composition of the brasses and steels would be. It is difficult to maintain the purity of the two last named, the brasses because of the tendency of the metals having the lowest melting points, tin or zinc, to liquate, or volatilise, and so separate from the copper; the steels, because they depend for their qualities on the maintenance of exact and very minute proportions of carbon and other elements. It would therefore be impossible to maintain the compositions of the brasses and bronzes, or of the grade of any steel, if either were melted in contact with the fuel as iron is.



116 THWAITES' CUPOLA FURNACE



Crucible furnaces [117] are built solidly of brick in the foundry floor, or they are of sheet iron or cast iron, brick-lined, and portable. The first are more suitable for the larger foundries, the second are often preferred in the smaller ones. There are very many variations in design, each of which may possess some slight advantage in some respect over others.

A small battery of the ordinary brick-built furnaces is shown in 117. It will be seen that each furnace can receive but one crucible, which rests upon and is surrounded with coke, and covered with an iron plate and tile during melting. [Compare with Carr's furnace [118] showing the crucible in place.] Natural draught comes up through the grate-bars, and passes away through the chimney common to all the flues. The fire is dropped at night by pulling out the loose grate-bars, which are made of rods of square section. The ashes are taken away from the ash-pit into the ash-hole or gallery in front, the grating being lifted up for the purpose.

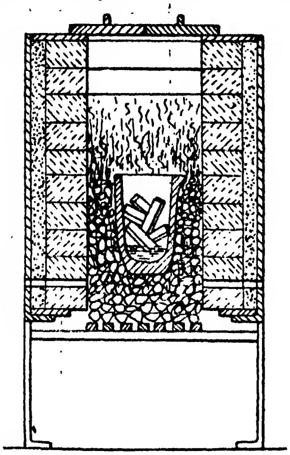
As a rule, the natural draught of a chimney is adopted for brass-melting furnaces, and coke is the fuel used. In recent years pressure blast has been applied to the Fletcher furnaces and others, and oil has been used as a fuel, as also has producer gas. It is probable that these will in course of time largely displace the old methods, because these agencies are more active, cleaner, and under better control.

Fig. 119 shows one of the Piat furnaces used largely in France. The actual furnace is made to tilt, so avoiding the pulling out of the crucible with tongs. In some of these, two crucibles are

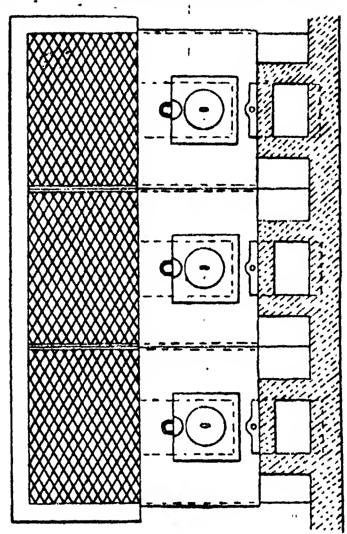
used, an upper one to warm the lumps of brass, and a lower one to melt them.

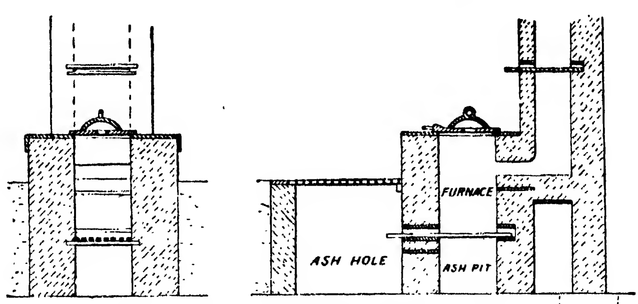
The Reverberatory Furnace. This and the brass-melting furnaces just described are often termed air furnaces, because they utilise natural chimney draught instead of pressure blast, like the cupolas and converters. The term "reverberatory" relates to the arched form of the furnace roof, which, being low, deflects the heat down on the metal that lies on the hearth.

Details of design vary, for these furnaces are used in nearly all metallurgical processes having for their object the reduction of various metals from their ores, or the remelting of metals and alloys. Essentially the furnace comprises a hearth on which the metal lies, and which is arched over by the roof; a fire-grate, separated from the hearth by a bridge of brick, and a tall chimney at the opposite end; and various openings in the furnace sides through which the operations going on are observed and controlled, and from which the metal is tapped. The flame and hot gases are drawn over the bridge and hearth by the chimney draught, and deflected by the roof on to the metal. The value of this type to the brassfounder lies in the fact that large masses can be melted without contamination with the fuel. The same remark applies to aluminium, and occasionally cast iron is so melted. The largest quantity of steel made is produced in furnaces of this type.



118. CARR'S CRUCIBLE FURNACE





117. BATTERY OF CRUCIBLE FURNACES

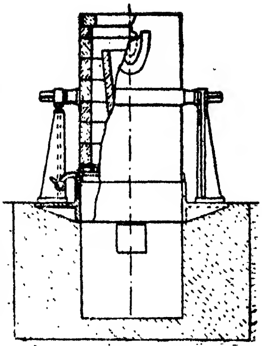
The Bessemer Converter. This is used in the manufacture of one particular grade of steel, used largely for castings, and for rolled products. It is a remelting furnace, the pig having been previously smelted from the ore elsewhere in a blast furnace, and remelted in a cupola before it is introduced to the converter. The pig is decarbonised, by the blowing of atmospheric air through the molten metal for about twenty minutes, and any excess of sulphur and phosphorus is removed, after which it is recarbonised by the addition of speigeleisen, or ferro-manganese (alloys of iron with carbon and manganese). It is then ready to be poured into the moulds. These converters deal with large and small quantities of steel, and divide favour with the open-hearth furnaces.

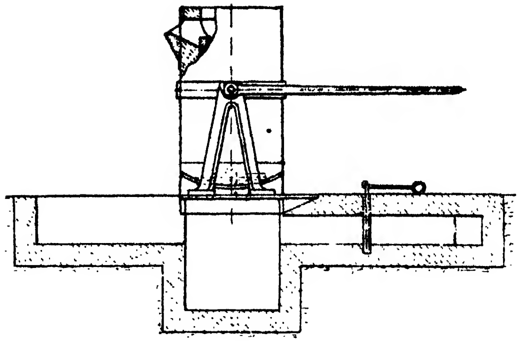
The Open-hearth Furnace. This is a reverberatory furnace designed with the special object of making mild steel from ore and pig or scrap. The ore and metal are decarbonised, not by a blast of air, as in the converter, but by the action of reducing agents—*fettling*. The metal is recarbonised by the addition of speigel, or ferro, and is then ready to be poured into castings.

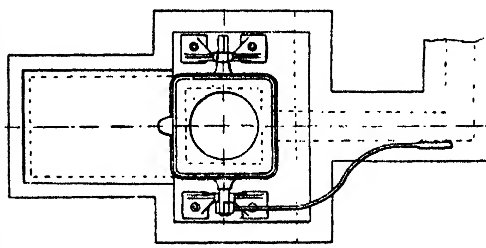
Foundry Ladles. In ordinary foundry work all metal is transferred from the cupola to the ladles before being poured into the moulds. These ladles vary in almost every respect one from another, from the small hand ladles, holding ½ cwt. to those carrying as much as 70 tons. The smallest is a hand ladle, usually made of cast iron, and furnished with one shank or handle. It is used for very light casts, and for supplying small quantities of metal required for feeding, etc. The form of ladle which is used more than any other in ordinary foundry work is the double-shank type, made in sizes holding from 1 to 3, 4 or 6 cwt. It is of sheet steel, riveted together, and is embraced by the ring into which it drops, and manipulated by the shank handle. Two, three, or four men are required for carrying it, according to its weight. With 1 cwt. or 1½ cwt. of metal two men suffice. With 2 cwt. or 2½ cwt. three men are required. Above this load four men carry, two at the double handle, and two at a cross-bar supporting the single handle. During carriage the heat of the metal is prevented from scorching the men's faces by a cover of sheet iron placed over it. The metal is poured by the man or men at the

cross-handle tipping it sufficiently high. Ladles of the same type, but carrying from 3 or 4 cwt. up to $\frac{3}{4}$ ton, are slung in the crane and tipped by men at cross-handles.

Heavy Ladles. Above this size, and up to 12 tons, ladles of the type of **120** are used. These are made of boiler plate riveted together, and according to their size the arrangements for pouring are modified. In any case the ladle is slung in the crane by means of a strong crosshead and eye; from the ends of the crosshead depend slings with eyes which embrace the trunnions projecting from a belt encircling the ladles about the centre. When the ladle is of moderate size, say, carrying less than 2 tons, it is tipped by means of the cross-handle having a box end and pin. But in the heavier ladles worm gearing, as shown in **120** (one of Nasmyth's numerous inventions) is always employed. In the figure bevel gears for gaining extra power are added. To give some idea of the enormous strain on this gearing, we may mention that we once saw the teeth of the worm-wheel of a 6-ton ladle strip while pouring, so that the mould was left half filled, and a waster casting resulted. Yet the ladle had been in use for many years. The spindle of the worm is usually prolonged and drawn down rectangular in form to receive the cross-handle, by which its rotation is effected Or, as in **120**, the cross-handle is put on the shaft of the first bevel wheel. The task of tipping, owing





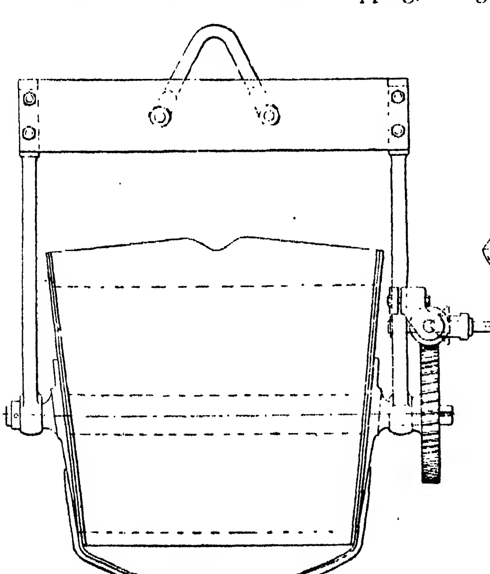


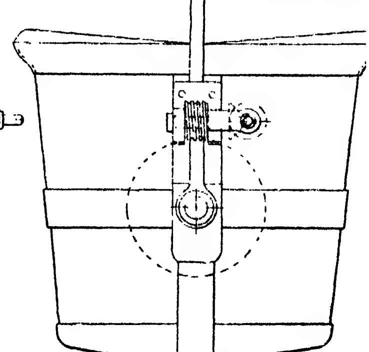
119. PIAT CRUCIBLE FURNACE

to the enormous gain in power obtained by this gearing, is comparatively easy, one man easily regulating the flow of several tons of metal. A forked bar is used for pulling round and guiding the ladle while slung in the crane.

The carriage form of ladle is employed for large quantities of steel, avoiding the use of a crane, the ladle being pivoted in bearings in a heavy carriage. Loads of molten metal up to 70 tons are handled thus.

Lining Ladles. A part of the duties of the furnace-man consists in lining the ladles in readiness to receive the metal. Clay wash is smeared over the interior, and afterwards a coat of sand and blackening, or of loam and blackening; then the ladles are dried, the smaller by being laid mouth downwards over a coke fire, the larger by having a fire of sticks lit inside them. After the casting is done, the remaining metal, if any such be present, and be not required for other work, is poured out into a gutter dug in the foundry floor, to be broken up after cooling. On the





120. GEARED LADLE

121. INTERIOR OF IRON FOUNDRY, WITH JIB CRANES

122. INTERIOR OF TYPICAL IRON FOUNDRY, WITH OVERHEAD TRAVELLERS AND WALL JIB CRANES

123. MOULDING A ROPE-WHEEL IN THE SULZER FOUNDRY

following morning the skulls, or thin linings of metal left adhering to the sides of the ladles, are knocked out, and they are relined for the next casting. One coating suffices for the casting of a single day, though the ladles may be filled several times, but not for the next day's work.

Skimming Ladles. Several special forms of ladle have been devised with a view to the better skimming of the metal, but the old form of baying the scoriæ back with a skimmer bar still holds its own. For casting steel the goose-neck ladle is generally used—that is, the metal is run through a hole in the bottom of the ladle, the hole being opened by a goose-neck or bent lever lifting a plug which closes the hole when not pouring. Another ladle has a partition passing down inside the ladle near to the bottom, which effectually keeps back the dross. Another on the same principle has two spouts on opposite sides. The only drawback to these skimming ladles is, of course, the extra trouble involved in daubing them up, an easy matter in those of plain form. The trouble of skimming is not so serious as some may think, for with a skimmer held firmly across a ladle's mouth it is very rare for any large amount of dross to flow over. And should any fall into the pouring basin it cannot go into the mould if the precaution be taken, as it always should be, to keep the basin full to the brim during pouring, because the lighter dross will float on the surface of the heavier metal.

Three typical foundry interiors are shown in **121, 122, and 123.** Fig. **121** includes a jib crane of the usual type, which covers the floor area within its range, piles of boxes being also seen. A larger building is illustrated in **122**, having the floor covered with overhead electric travellers, for handling ladles of metal, and large boxes and castings. On the left-hand wall, jib cranes are provided, for use while the travellers are busy elsewhere. Fig. **123** gives a close view of the moulding of a large rope-wheel at the Sulzer foundry, Winterthur, a segment of the central core being lowered by the crane into place.

Continued

CYCLOPÆDIA OF SHOPKEEPING

GLOVERS AND HOSIERS. Nature and Opportunities of the Trade. Premises and Fittings. Capital and Stock. Prices and Profits

GREENGROCERS. Requirements of the Business. Where to Buy and How to Sell. Vegetables and their Seasons. Profit

GLOVERS AND HOSIERS

The business of a glover and hosier is an ideal one for a smart young man who knows the trade well. It affords scope for enterprise; it may be entered into with only moderate capital; rapid changes in fashion do not make risky and unsalable stock, as in some other departments of the soft goods trade, and the return for energy expended and capital invested compares well with other branches of retail shopkeeping.

Locality and Premises. As an independent venture, and not merely as a department in a general drapery or outfitting business, a glover and hosier's shop should be opened up in a city or large town, and in a shopping thoroughfare frequented to some extent by fashion. A working-class population may buy hose, but gloves are luxuries of which their puchases are sparing, and the glove side of the business is the more profitable.

A prominent lock-up shop in a good city thoroughfare may be had at a rental of £150 a year, but cannot be well had for less. Even at this figure the shop will only be single-fronted, with one window. The outside should be neatly painted black, and a glass facia and stall board, with gold lettering, provided at a cost of about £10.

At present there is a marked tendency towards light colours—cream, for instance—for both outside and inside decoration, but black, especially for the outside, shows a more artistic taste, and harmonises better with the stock. The window should be properly cased in, and one side should be fitted with a large mirror placed slightly on the angle. A good arrangement of movable brass rods and brackets ought to be fitted. The entire window interior will cost about £15 for fitting. All woodwork inside the shop ought to be painted black; the ceiling may be cream coloured, and the walls washed with a grey distemper paint.

The counter should have a flat glass case; the combination may be bought for £10 or very little more. A glazed wall case will cost about as much. Suitable shelving for stock boxes and parcels of hosiery are essential. The entire floor should be covered with linoleum. A good rug should be placed in front of the counter case, and a few bentwood chairs are required. The electric light should be installed in preference to any other if it be available. It is cleaner than gas, and permits of colour-judging much better.

The window is the most important feature in the business, and should have attention accordingly. It offers the lure for the casual purchaser, and however big the regular trade may become, the casual trade, through the efforts of a competent window-dresser, will be bigger still. Original window effects should always be striven for, either in form or in colour of treatment.

Capital and Turnover. A stock of the value of £250 will suffice if carefully selected, and if the various classes be represented in their proper proportions. It should be turned over six times a year, which is more frequently than most other trades, and explains the moderate capital of our estimate. The profits should be about 33⅓ per cent. upon the selling prices, which means 50 per cent. on cost prices. Thus the turnover on a stock of £250 would be £1,500 per annum, and the gross profit would be £500, leaving, after the deduction of rent and other dead charges, a good return upon the capital invested. The estimate of 33⅓ per cent. being a minimum profit, actual working would show better results than those stated, depending in amount upon the excess profit over the 33⅓ per cent.

Stock. There are two seasons in both the hosiery and the glove trade, demanding two distinct classes of goods—winter and summer—and stock must be bought according to the seasons.

The stock must be very varied, and all sizes in ladies', gentlemen's, and children's wear must be kept. The good makers, such as Dent and Fownes, must be represented, but a speciality should be made of "own make," which may be made more remunerative, and every pair of which is an advertisement for the retailer.

Gentlemen's Gloves. Gentlemen's stock will comprise gloves for driving, hunting, motoring, and walking, in real Cape, buckskin, and reindeer, retailing at from 3s. 6d. to 7s. 6d. per pair, and varieties in washleather, kid, suède, and chevrette, to sell at 2s. 6d. to 3s. 6d. per pair. Winter goods will include gloves in Cape, buckskin, Mocha, and reindeer, lined with silk, wool, or fur, and retailing at from 3s. 6d. to 10s. 6d. per pair. Then there are knitted ringwood gloves in black, white, and colours, at 1s. 6d. to 2s. 6d. per pair, and dress gloves in white Lisle thread and silk, in Paris kid, and lama—both white and lavender, at from 1s. per pair.

Ladies' and Children's Gloves. Ladies' gloves demand a greater variety than gloves for gentlemen. The stock must include plain kid gloves in two, four, and six button, to sell at 2s. 6d. to 5s. per pair, and suède gloves in four and six button in black, white, tan, beaver, slate, and drab, to sell at from 2s. 11d. to 5s. Other items in the selection held will include chevrette,

reindeer, and doeskin gloves, silk, wool, and fur-lined gloves, motoring, driving, and gardening gloves, silk-lined kid gloves and evening gloves—black, white, and light fancy colours—both in kid and suède, up to 20 buttons in length, and selling at 3s. 9d. to 10s. 6d.

Children's gloves in all sizes, both for boys and girls, form the third section of the glove stock. It is the least profuse in variety, and durability rather than fashion is the standard of acceptance in children's gloves, and the stock must be selected with this fact in mind.

Making and Cleaning Gloves. Enterprise is often profitably directed by encouraging the "Gloves made-to-measure" trade. It is more remunerative than retailing ready-made gloves. Sometimes a side window in which a man works cutting out gloves may be instituted with advantage. A girl, or more than one, may be kept to sew the gloves together, or they may be given out to be sewn. In any event, the glove-cutter at work is always a good "draw," and inspires the confidence of the purchasing public.

Then, glove cleaning should be undertaken, and emphasis laid on the "new odourless process" of cleaning, as many customers have unpleasant recollections of having had gloves cleaned and returned to them in a state that might please the eye, but distinctly offensive to the nostrils.

Adjuncts to Glove Selling. It is always profitable to hold in stock a good selection of fancy glove boxes to hold three, six, or 12 pairs of gloves. Gloves are favourite articles when presents are given, and a dainty box can often be sold with gloves bought for presents. As business develops and capital increases, many other branches may be added to the business of which the retailing of gloves is still the backbone. Such branches include general gentlemen's outfitting goods, braces—garters are allied articles—fans, lace mittens, ties and scarves, handkerchiefs, perfumery, bags and trunks, and other fancy departments. Many of them are the subjects of special consideration in other articles in this course.

Hosiery. The word *hosiery* embraces all varieties of knitted articles of wear. Only small quantities of each article should be purchased, as the stock can be replenished within 24 hours, if the retailer be in London, and within two days if his shop be in a provincial town. Like the glove stock, hosiery may be divided into three departments, those for ladies, gentlemen, and for children.

In the gentlemen's department there must be stock of hand-knitted stockings, jerseys, sweaters, knitted waistcoats and Cardigan jackets for golfing, cycling, and boating; also undervests, pants, socks, nightshirts, and combinations in unshrinkable natural wool, fancy coloured cashmere, spun silk, merino, cotton, lamb's-wool, Indian gauze and silk and wool.

Ladies' hosiery embraces combinations, undervests, drawers, nightdresses, spencers, bodices, and a large variety of hose—plain, ribbed, and embroidered in the various materials already enumerated. For children the hosier must have a good selection of combinations, vests, drawers, nightshirts, socks, three-quarter hose, and stockings in all sizes and kinds for both boys and girls.

The profits in the hosiery department will not be quite so high as in the glove department. The retailer will seldom be able to exceed the rate of profit already given—33⅓ per cent. on selling price—and occasionally he will be below it. He is fortunate if he maintains that level on an average.

Assistance and Terms of Selling. The business is one where unremitting personal attention is imperative. The wage bill need not be large until the turnover requires the services of more than one expert salesman. A boy as an outdoor apprentice, beginning at 6s. per week and rising to 10s., and an errand-boy at 6s. will be sufficient until a good footing be gained.

The trade will be almost exclusively cash and may be entirely so. Hence there is little time and expense required in bookkeeping, and bad debts will be trifling.

The cheap sale should be an annual or a semi-annual feature. It makes room for new stock and it brings new customers to the counter, and will be profitable. It does not follow that all the reduction in prices at a spring or an autumn sale come from the profits of the retailer. The wholesaler and the manufacturer have often remainders and job lots at low prices which just suit the sale time and enable the retailer to secure his usual profit although apparently selling at a great sacrifice.

GREENGROCERS

The sale of vegetables is one of growing importance, for there is an ever-increasing tendency towards the simpler, non-flesh-eating life and the consumption of vegetable produce. To the young man, therefore, with a good constitution and a working knowledge of the business, it offers a fine field for intelligent enterprise. Experience is obtained in the markets and in the fields, but, more particularly, in the shop of a greengrocer with a good-going family business. The necessary knowledge is thus easily acquired by a smart, wide-awake man, and provided he has also been prudent and careful to the extent of saving £50 or £60, he may fairly consider himself equipped for a start on his own account. If, besides these qualifications, he has acquired a partner in life to share his joys and sorrows, and to help him in his business, so much the better.

The Beginning. With so small a capital, it will be evident that a large shop, in a high-class suburb, need not be aimed at. The shop to acquire would be a small single-windowed one in a residential middle-class neighbourhood, but one of the main things to look for is a shop with a short forecourt in front, or at the side, where permission will be given to display part of the goods outside on trestles. The fitting up of the shop and the necessary utensils would not cost more than £20 to £30. A number of

large bins are required for holding onions, cabbages, potatoes, and other staples. These are arranged around two sides of the shop, according to the space, and over these are erected two or three rows of wooden shelving to hold baskets and other sundries. The window should have a sloping bottom, and a counter may or may not be thought necessary. The window is filled with baskets, trays, or boxes, in which tomatoes, asparagus, nuts, and so forth are displayed. If a glass wall-case can be secured cheap, either new or secondhand, it lends an increased attraction to the establishment, and is useful in storing bottled vegetables, preserved fruits, sauces, and other culinary adjuncts. At least two sets of scales and weights will be required; a large size—weighing up to 28 lb.—for vegetables, and a smaller size with brass pans—to weight up to 7 lb.—for the smaller vegetables. The larger scales would probably cost about 25s., and the smaller 15s., and care should be taken that they are adjusted periodically, and that the weights are true. By paying a sum of 10s. or 12s. yearly, certain firms undertake, in London and other large towns, to adjust scales and weights four times a year, and thus obviate unpleasantness as a result of unexpected visits from the local inspector of weights and measures. Baskets are also a necessary part of a greengrocer's equipment. The beginner would buy half a dozen small baskets, costing from 1s. 3d. to 2s. 6d. each, and half a dozen larger ones, costing from 2s. to 3s. 6d. He would also probably invest in a hand-barrow. If he felt particularly adventurous, he might go in for a specially-built hand-barrow, likely to last him a lifetime, which would cost something like £10 10s.; but probably £3 for an ordinary coster's barrow would be nearer the mark. Barrows may be hired in London and other big towns for 1s. a week. A supply of paper bags, with name and address printed on the outside, and capable of holding from 1 to 7 lb. of contents, would cost at least £2.

Marketing and Credit. Assuming that the beginner is a shop-owner in a metropolitan suburb, and that he has his shop ready for stock, he would hire a horse and van, and a driver, at a cost of from 3s. to 6s. per journey, and start out about four or five o'clock in the morning for Covent Garden to buy his stock. He would go to the market at least three times a week on this errand. In buying, he must keep in view the fact that the goods he deals in are extremely perishable, and make allowance accordingly. He should be careful not only to buy as keenly as the market will allow, but also to see that the goods he buys are fresh, sound, and of good quality. He will find it advantageous from every point of view to pay cash at first for his purchases. As his retail trade must likewise be for cash down—at first, at least—this will be no hardship, seeing that an energetic man must sell his stock twice, or at least once a week, in order to avoid loss by deterioration. Therefore, he will always have money in hand to go on with. As he begins to know his neighbourhood and his customers, he will probably find it necessary to give weekly credits, and for this purpose he will have to provide a set of pass-books—costing about 6d. each—with his name and address printed on, for the use of credit customers. Another item to be taken into consideration is the fact that some kinds of vegetables are bought in baskets, for which the wholesaler charges 1s. or 6d. each, giving the retailer a tally for the amount, and if the baskets are returned within 14 days, the money is refunded. He should see to it, therefore, that these baskets are not kept beyond the proper time, or he may lose money in a simple way.

A Specimen Order. The season of the year has, of course, much to do with the kinds and quantities of vegetables to be purchased for an opening stock. But, supposing a start be made at the beginning of the year, the young greengrocer would select first of all one ton of potatoes, which would cost him probably something under £5, at average Covent Garden January prices. The ton would be divided into three kinds, the best (to retail 14 lb. for 1s.), second-rate (selling at 18 lb. for 1s.), and third-rate (4 lb. for 2d.). Other purchases would include one dozen bunches of carrots, costing, approximately—as with all the prices cited—2s. 6d., to retail at 4d. per bunch; one cwt. bag of Dutch onions (cost 3s. 6d., retail 1d. per lb.), one case Spanish onions (7s. 6d.) and one cwt. English onions (5s. or 6s.). The Spanish and English varieties retail usually at 5 lb. for 6d. Turnips would be bought in the same quantity and at the same price as carrots; celery, six bundles (eight in a bundle) cost 5s., retail 2d. per head; a few Swedish turnips (retail 4 lb. for 2d.); one bushel of Brussels sprouts (3s. to 3s. 6d., retail 1½d. to 3d. per lb.); one tally (60) savoys (costing, according to size, 3s. to 6s., retailing at 1d. to 2d. each); one bag of bunch greens, loose or cut (costing 1s. 6d. to 2s., and retailing at 1d. per lb.); a similar quantity of broccoli (retail, 1d. each); some red cabbage and French beans; two dozen lettuces (1s. 6d. per dozen); one dozen bunches watercress; half-a-dozen punnets mustard and cress; half-a-dozen endive; two bunches of spring onions; one dozen bunches of leeks (cost 1s. 6d., retail 2d. per bunch), some garlic and shalots. Continuing, he would select two dozen cauliflowers (costing 2s., retailing at 3d. each); three 1 lb. baskets seakale (costing 1s., retail, 6d. per lb.); a bushel basket of beetroot (cost 2s., retail 1d. each raw or 2d. to 2½d. each boiled), two bushels turnip-tops (cost 1s. 9d., retail 1d. per lb., or 3 lb. for 2d.); two dozen bundles forced rhubarb (cost 2s., retail 2d. per bundle); winter spinach (retail 4d. per lb.); three or four punnets of forced mushrooms (costing 8d. per punnet or lb., and retailing at 1s.). It will be necessary also to lay in a stock of nuts, say one dozen quarts of Spanish (cost 3s. 6d., retail 6d. per quart) and same quantity of Brazil nuts, which retail at 7d. per quart, and cost a little more than the Spanish. A nice selection of walnuts, almonds, dates, figs, and other dried fruits is also requisite, besides the principal fruits in season. These are dealt with in the article on Fruiterers [page 2529]. Many things

are not mentioned in this list, such as asparagus, artichokes, in the purchase of which the green-grocer will have to use his judgment after gauging the potentialities of his customers.

Vegetables in Season. In the foregoing paragraph, the stock is such as would be bought in January. But every month there is something new to be added to, or to be dropped out of, stock. Moreover, the crops are sometimes bad, and the vegetables scarce; at other times the crops are good, and the supply plentiful. This naturally affects the prices, both wholesale and retail, making things dearer or cheaper, as the case may be. For instance, peas are generally cheap in June and July, because the English season is then on, and the exotic supplies still coming in help to glut the market. In June, therefore, the greengrocer would pay 4d. per peck in the market for peas, and retail them at 6d. per peck, while in March or earlier, he would pay 1s. per peck and sell at 1s. 6d., but the usual average price for good peas would be 1s. per peck, and the cost about 8d. The appended table gives approximately the seasons at a glance.

	Months when in Season.
Artichokes..	July to March.
Asparagus..	May to September.
Beetroot ..	October to March.
Broccoli ..	December to April.
Brussels sprouts	August to March.
Cabbages ..	May to March.
Carrots ..	October to March.
Celery ..	October to May.
Chervil ..	January to March.
Cresses ..	January to May.
Cucumbers	January to July.
Endive ..	January to March; July.
Kidney beans	February and March.
Lettuces ..	January to August; Oct. and Nov.
Leeks ..	December.
Mushrooms	July, August, and October.
Onions ..	April (young); June to December.
Parsnips ..	Jan. to March; June to Aug.; Dec.
Peas.. ..	May to August.
Potatoes ..	May (early) to March.
Radishes ..	April to June; August.
Rhubarb ..	April and May (natural); Dec. to April (forced).
Savoys ..	August to January.
Scotch kale	December.
Seakale ..	March to August.
Spinach ..	Every month *except* May and Oct.
Tomatoes ..	September and October.
Turnips ..	January to March; July to Oct.; December.
Vegetable marrows	July to October.

It will be understood, of course, that the "season," as given in the foregoing table, means the season of the year in which the English housewife uses home-grown vegetables only. There are many—probably most—of the vegetables named that are obtainable all the year round—potatoes, tomatoes, and onions, for instance. But in the months not named, the vegetable then procurable is not usually of British production.

Suitable Side Lines. Besides the fruits, etc., already referred to, there are many other developments of the greengrocer's business possible. He may trench on the domain of the fruiterer with impunity, selling all that the fruiterer sells. He may even invade the special province of the florist and the seedsman, and sell cut flowers, flowers in pots, ferns in pots, flower seeds, bedding plants, and so on. As the business grows, the greengrocer may rise to the dignity of a horse and van of his own, and in spare time this can be made remunerative by undertaking local removals and the general work of a carrier. Then there are appropriate culinary necessities, such as vinegars—to sell "loose" from the cask or in bottles—bottled sauces and oils, bottled vegetables and fruits, pickles, olive oil, dried herbs in bundles, and mixed herbs in packets. At Christmas time, when the stuffing of geese and turkeys is universal, the sale of dried herbs, like sage and thyme, is not to be despised.

Searching for Business. In these days when competition is so keen, it behoves the beginner to bestir himself and look out for orders. It is of no use to stand in the shop and expect the neighbourhood to flock to your establishment when there are countless peripatetic vendors of vegetables and fruit in the shape of persistent costers, who buy the "left" stocks in the market for next to nothing, and who vend particular articles from door to door in your neighbourhood at probably cheaper prices than you are selling in your rented shop. It will be imperative, therefore, either to go personally, or to send out a boy every morning to solicit orders for the dinner vegetables needed by the residents of the neighbourhood. Moreover, as a greengrocer invariably makes a reputation on his potatoes, great care should be taken in the selection of these. A sample of a fine "floury" potato, ready cooked, should be on view on a clean plate in the shop. If a freshly-cooked "mealy" potato is displayed in this way every morning it will act as a surprising incentive to business.

The Question of Profit. The perishable nature of the greengrocer's stock makes it necessary that it should be worked with great care and circumspection. On occasion, even the most careful man will buy a quantity of potatoes or other vegetables in which some of the stock, overlooked in buying, are rotten or diseased, and these quickly contaminate the entire parcel. There are other unforeseen and unavoidable incidents in stocking vegetables that make for waste. In a business such as we have sketched, the amount of waste incidental to the business could not be reckoned at less than £1 per week. This has to be kept in mind when marking retail prices. The rent of shop, with living accommodation, rates, etc., would be at least £60 per annum, and a shop-boy will cost—in London—7s. to 10s. per week, according to his size and capacity. A man must reckon, therefore, on having a profit of from 30 per cent. to 40 per cent. on his return before he can make the business pay. Some may do it on less profit, but we are supposing that the young greengrocer and his wife are starting out in life with the intention not only of making a livelihood, but of gaining a competency by thrift, earnestness, and energy.

Continued

continued from

OVERCOATS AND WAISTCOATS

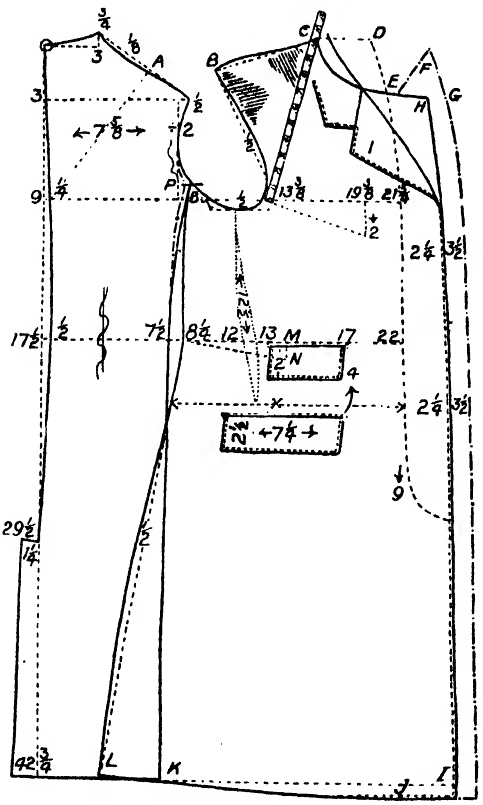
System of Drafting and Cutting Chesterfield Overcoat. Four Styles of Vests. Cutting Material from the Cloth. Trimmings. Some Hints on Making

By W. D. F. VINCENT

Overcoats. The most popular style of overcoat is the Chesterfield, and we show how to cut this in two styles—the "fly" front and the "double-breasted." Overcoats, of course, require larger shoulders and larger body parts than the ordinary suit coat, as well as extra spring over the hips. This is provided for by increasing the front and over shoulder measures ⅜ in., allowing an extra inch a side for making up and adding about 1 in. more spring at the hips. In order to make this clear we give the system complete.

Draw lines at right angles to 0 [22]. 0 to 3, ⅓ scye depth; 0 to 9, depth of scye; 0 to 17½, natural waist length plus ½ in.; 17½ to 29½, from 9 to 12 in.; 0 to 42¾, full length plus ½ in. Square lines at right angles to these points. 17½ to ½ is ½ in.

Draw back seam from 0 through ½ to 29½. Mark back from 29½, 1¼ in., and draw line from 0 through it to bottom. 0 to 3, one-twelfth breast; 3 to ¾, ¾ in. 2 in. below 3 mark off the width of back plus ⅜ in., and curve out to ½. Draw shoulder seam from ¾ to ½; ¼ to 21¾, half chest plus 3½ in; 21¾ to 13⅜, the across chest plus ⅜ in.; 13⅜ to 19⅜ is always 6 in.



22. CHESTERFIELD OVERCOAT

19⅜ to 2 is 2 in., more for stooping figures and less for erect. Square up from 13⅜ and 2 in the direction of C. 13⅜ to C the front shoulder length, plus ⅜ less 0 to 3 of the back. 13⅜ to B the over shoulder measure, plus ⅜ less ¾ to A of the back; C to B, ¼ in. less than back shoulder.

Shape scye by these points, dropping it ½ in. below line 9; ¼ to 7½ is about one-sixth breast plus 1 in. Square down from 7½ and continue up into back scye; 7½ to 8¼ is ¾ to 1½ in. according to the closeness of the fit desired. 8¼ to M is 6 in. M to N, 1 to 2 in., according to the amount of spring desired.

Square down by 8¼ and N and add on ½ in. of round. Take out a fish under the arm of about 1 in.

When this is omitted reduce the back as per dot-and-dash line at P.

C to D, one-twelfth breast; D to E, the same quantity. Draw breast line from D through 21¾.

Make waist to measure, plus 3½ in.; add on 2 to 2¼ in. in front of breast line and complete as shown. Drop fore part ¾ in. at J.

For double-breasted fronts add on 3½ in. in front of breast line and complete as per dot-and-dash line. Shape lapel at F G to taste.

Locate pockets as shown—ticket pocket on waist level and the front level with the front of hip pocket. Hip pocket 4 in. below waist. The centre of the pocket is X, and this is midway between side seam and breast line. Size of ticket pocket flap, 4 by 2; hip pocket flap, 7¼ by 2½.

The system for cutting the sleeve is the same as described for cutting the lounge jacket, but the measure from 2 to the depth of scye line must be measured to the true level of the bottom of the scye. The width at elbow and cuff must be increased by fully ½ in.

Waistcoats. Several of the measures taken for the coat are used also for the vest, with the addition of a measure taken from the back neck A [24] to the opening B and on to the full length C. The chest and waist measures illustrated in this figure at D and E are the same as for the coat. From the sectional measures taken for the coat we make these deductions. Front and over shoulder measures ¼ in., across chest ½ in.

THE BACK. Draw lines at right angles to 0 [23*a*]; 0 to 9, scye depth; 0 to 17, natural waist length; 17 to 1, 1 in.; draw line from 0.

From 1 mark in ¾ in., and draw back seam 0. ½ to ¾; 0 to 2½, one-twelfth breast less ½ in.; 2½ to ¾, ¾ in. Make ½ a pivot and sweep from

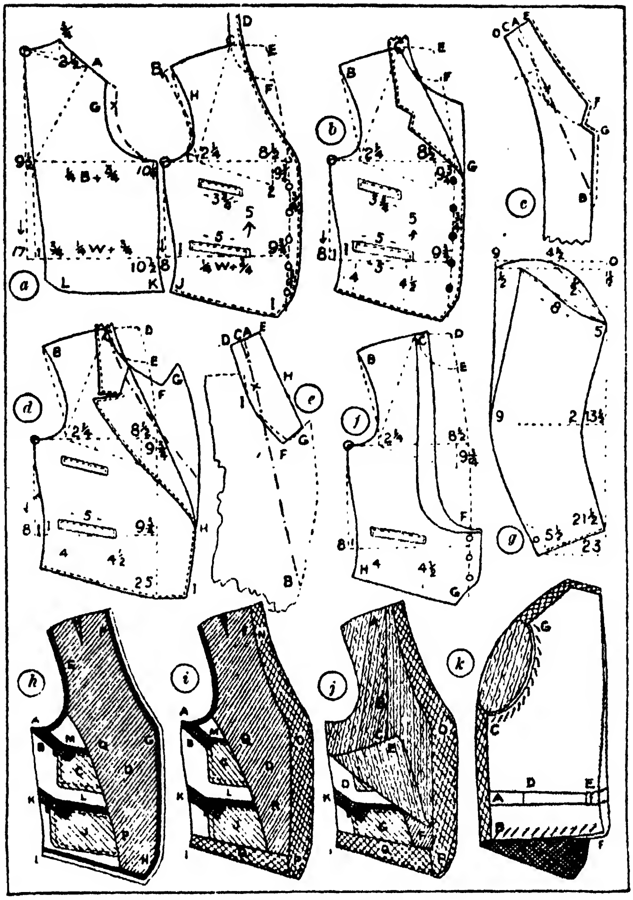
0 to A. Make width of shoulder one-eighth of breast plus $\frac{1}{2}$ in.; $\frac{1}{4}$ to $10\frac{1}{2}$ is $\frac{1}{4}$ of breast plus $\frac{3}{4}$ in.; $\frac{3}{4}$ to $10\frac{1}{2}$ is $\frac{1}{4}$ of waist plus $\frac{3}{4}$ in.

Draw back scye and side seam, leaving the length of back to be adjusted after the fore part has been cut.

THE FORE PART. Draw lines at right angles to 0; 0 to 8, the distance between depth of scye and natural waist; 8 to 1, 1 in. for all sizes. Draw side seam. 0 to $9\frac{3}{4}$, $\frac{1}{4}$ of breast plus $\frac{3}{4}$ in.; $9\frac{3}{4}$ to $2\frac{1}{4}$, the width across chest (the $\frac{1}{2}$ in. having been deducted as before stated); $2\frac{1}{4}$ to $8\frac{1}{2}$, $5\frac{3}{4}$ in. (always); $8\frac{1}{2}$ to 2, 2 in. (less for erect, more for stooping figures). Square by $2\frac{1}{4}$ and 2 up to C; $2\frac{1}{4}$ to C, the front shoulder measure less the width of back neck; $2\frac{1}{4}$ to B, the over-shoulder measure less $\frac{1}{2}$ in., to A of the back, $\frac{1}{4}$ in. having been deducted from each; C to B a trifle less than back shoulder; C to E and C to F, one-twelfth of breast less $\frac{1}{2}$ in.

Draw breast-line from E, through $9\frac{3}{4}$, to hollow. Shape scye from B to 0; 1 to $9\frac{3}{4}$ is $\frac{1}{4}$ of waist plus $\frac{3}{4}$ in. Add $\frac{3}{4}$ in. for button stand beyond $9\frac{3}{4}$.

Measure off the length to opening from C to breast-line, having first deducted the width of back neck. Continue on to I the full length, allowing $\frac{3}{4}$ in. for seams. Place one arm of the square on C, and the other on I, with the angle at side seam, and draw the run of the bottom of vest. Complete back length to harmonise with fore part.



23. WAISTCOATS

The style shown in this diagram is a "no collar vest," and for such the neck is filled up $\frac{3}{4}$ in. at C, which means that the stand of the collar is cut on to the neck. The pockets are placed on the level of waist about 5 by $\frac{3}{4}$ in., and are kept about 1 in. in front of the side seam. The watch pocket is put about 5 in. above the other, and is made about $3\frac{3}{4}$ by $\frac{3}{4}$ in. to slope up. The usual number of buttons placed up the front is six.

Step Collar Vest. The cutting of this fore part is identical with the preceding one, except at the neck, which has the neck cut down, as from C, to a little below F, the part above C being arranged in harmony with the shape of the lapel desired [23*b*].

THE COLLAR. B, $\frac{1}{4}$ in. above top buttonhole [23*c*]; X is $\frac{3}{4}$ in. up from hollow of gorge. Draw line from B through X to A. A to D, depth of fall; D to C, depth of stand; C to E, depth of fall. Length of collar, sufficient to go round the back neck. The facing and collar cover are usually cut in one piece, as indicated by dotted line E F G.

Double-breasted Vest. Similar to fore part of Diagram *b*, but with an extra amount added for overlap, as from $9\frac{3}{4}$ to H and 25 to 1, adding, say, $2\frac{1}{2}$ in. at H and $1\frac{3}{4}$ at I [23*d*]. Curve up the bottom slightly, as from 25 to I. Shape the lapel to taste at F G, or the neck may be cut down to the dot-and-dash line, and the upper part filled in with silesia. The collar for the double-breasted vest is shown on Diagram *e*, except that the shape at F G is different; that, however, is quite a matter of taste. B is $\frac{1}{4}$ in. above the top button; X to $\frac{3}{4}$ in. from 1.

Draw line from B through X to A. A to D, depth of fall; D to C, depth of stand; C to E, depth of fall. Let collar overlap gorge $\frac{1}{4}$ in. at F, and let G touch the top of lapel.

Dress Vest. Similar to 23*a*, with the neck filled up as for "no collar." F is the opening; mark back from breast-line $2\frac{1}{2}$ to 3 in., and draw line up to $\frac{3}{4}$ in. front of C; fill in the corners $\frac{3}{4}$ in., and shape opening to taste [23*f*].

The collar for this is cut the same shape as the opening from C to F. The shape imparted at G is a matter of taste.

Sleeve Vests. Back and fore part as 23*a*, but with the shoulder made one-sixth of the breast, and the scye filled in as dot-and-dash line.

The Sleeve [23*g*]. Mark sleeve pitches; back, 2 in. down from shoulder point; front, ¾ in. up from bottom of scye. Draw lines at right angles to 0; 0 to ½, ½ in.; ½ to 5, back pitch to depth of scye line.

0 to 9, size of top scye between the two pitches, with the shoulder seam put in a closing position. 0 to 4½, half 0 to 9. Shape sleeve head as illustrated. Measure off length to elbow and cuff from 9 to 9 and 5½. Hollow elbow 2 in. at forearm; make sleeve width of elbow one-sixth breast plus 1 in., and cuff one-sixth breast less ½ in.; raise forearm at cuff 1¼ in. 5 to 8 is the size of the underscye between the two pitches. The undersleeve must not be "hollowed."

Making Up. The welt pockets are put in in the same manner as for a coat, the ends tacked to stays as shown at B and K of Diagram 23*h*. J shows the lower pocket, C the watch pocket. Q and P front tackings of the pockets through the canvas. D shows the canvas, and it will be noticed that a V of the same material has been inserted at the shoulder to impart form.

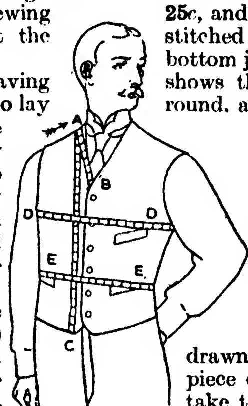
F G H I shows the stay tape put round the edges to steady it and to draw it in a little at G and H. E and A show the scye turned over.

Diagram 23*i* shows the next step, the facings being sewn on and turned over as illustrated at N O P Q. This is then seamed on to the canvas. Diagram 23*i* shows the fore part linings being put in; a fold is put down the shoulder at A, and the lining is then felled on to the scye and the facings. Diagram 23*k* shows the back sewn to the fore part. G to C is basted round on the outside, and B to F along the bottom to keep it in place for the press. The buckle and strap is put on at the waist level and is sewn in with the side seams.

The finishing touches may now be given—such as working the buttonholes, sewing on the buttons, and giving the vest the final pressing.

Cutting from the Cloth. Having cut out the patterns, the next step is to lay them down on the cloth so as to take them out of the cloth as economically as possible, and at the same time to arrange them in such a way that they will not be unduly biassed, whilst in the case of prominently checked materials it is necessary to arrange the corresponding seams to match.

First arrange the cloth with the way of the wool (if there is one) running from right to left, and then note if there is any string along the selvedge, as this usually indicates a damage and has to be avoided. Then arrange the various parts on the material, with due allowance for the necessary inlays. In Diagram 25 we show how to take a 36-in.-breast lounge suit out of 2¾ yd. of faced material, with all the usual inlays provided and very fair facings. This is practically self-explanatory if the student understands that F is the fly, V F the vest facing, T F the top flap, etc. 37 in. is reckoned to the yard, that being the universal standard adopted by woollen merchants.



24. VEST MEASUREMENTS

Trimmings. The following trimmings are required: ¾ yd. of canvas, ½ yd. of silesia—to match—for pockets, striped sleeve lining to length of sleeve, 5 or 6 in. of linen, lining according to garment, buttons, twist, silk, coat-hanger, stay, tapes, etc. These are generally rolled up in the canvas and tied with the stay tape. The ticket containing the instructions to the workman is made out, and the garment handed over to be made up.

Hints on Making. The garment is usually unrolled and the ticket studied as a preliminary, the trimmings are checked off, and the marking threads put in, and then the shoulders are manipulated by the iron. The shoulder is folded over down the middle and moistened with clean water, and the iron worked backwards and forwards so as to form a hollow [25*i*]. This will result in stretching the gorge and the front of shoulder, and shrinking the hollow of the shoulder.

Now baste a strip of linen across the back of the pocket mouth, as shown in Diagram 25*f*, and later put another strip to go from the end of the pocket mouth into the side seam, as B. A should, of course, go on the straight, and B on the angle, the threads of the linen being arranged so as to provide the utmost support.

The flap is then cut to the size and shape desired, lined and stitched in the same style as the edges are stitched. Then place the flap down on the outside of the fore part, as F B [25*b*], and on the top of this put a piece of pocketing, as A, and then stitch through all the parts at A. Underneath a piece of pocketing has been seamed on to a narrow strip of cloth which, in turn, is stitched along the bottom of the pocket mouth.

The pocket mouth is then cut through between the two rows of stitching, as shown in Diagram 25*c*, and each of these is then turned in and stitched along the top. Diagram 25*d* shows the bottom jeating turned in and stitched, and 25*e* shows the flap. The pocket is then stitched round, and the stays are basted on [25*a*].

The canvas next claims attention, and, in order to get the best shape into this, "V's" are inserted at neck, shoulder, and scye [see W, 25*a*]. For these slits are made with the scissors at the most suitable parts, and then V's of canvas are inserted and opened out. The pocket ends may now be tacked. The edges are then steadied or drawn in a little with stay tape, and a piece of linen is put down each front to take the buttons and holes. A strip of linen is put along the crease row—this is known as a bridle, its object being to prevent stretching at that part. The lapel in front of this is padded to give it a nice curve, and the fronts are ready for their pressing, which should be done before the linings are put in.

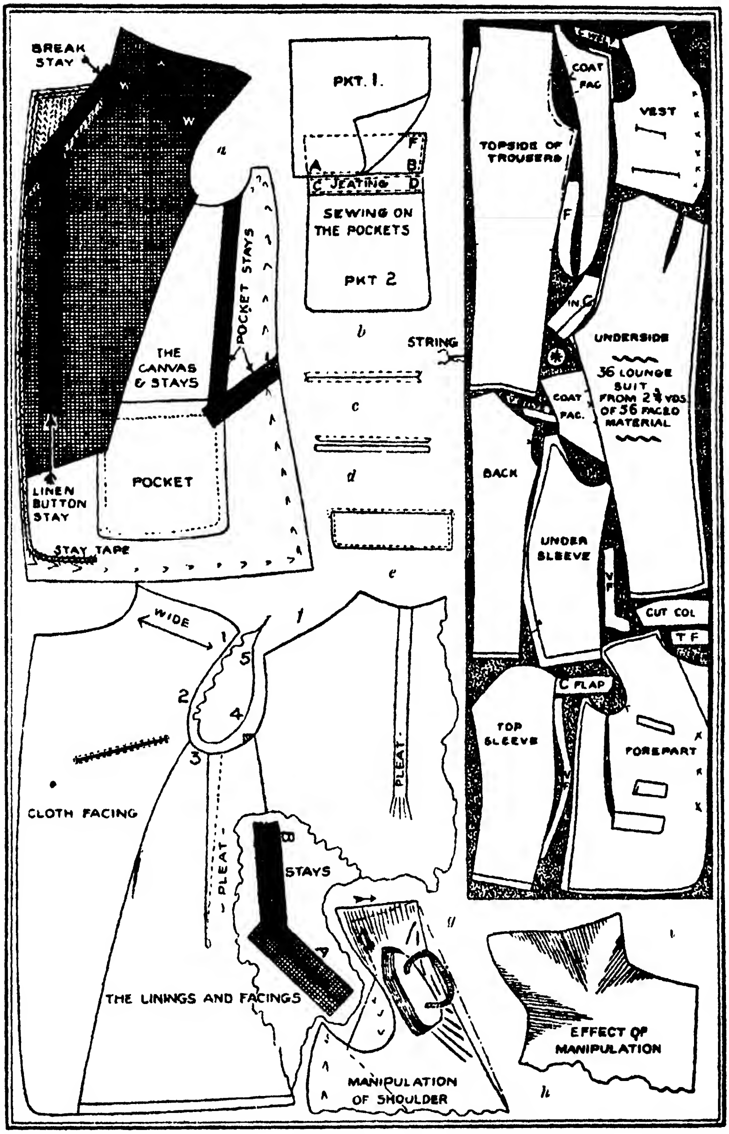
In putting in the linings, it is necessary to allow extra width to the facings across the shoulders, and to provide a pleat down the centre

of the back and under the arm, as marked in Diagram **25f**. The facing on the turn must also be put on extra long and extra wide, so that it may lie smoothly when the lapel is turned back.

The shoulder seams are sewn, and the collar put on, keeping it fair across the back, long in the hollow of the gorge, and rather short in the front. The collar is made up on canvas, with the stand stitched and the fall padded to give it the proper curl. To get both ends of the collar alike, put a seam in the centre of back and cut the front ends where it joins the neck on the straight.

The outside collar is cut without a seam in the back; it is worked into shape by the iron, and put on long enough to cover the inside collar. The seams are usually drawn together. The edges are stitched, and in doing this it may be necessary to turn it at the start of the lapel.

In putting in the sleeves, the pitches must be first indicated; this is usually done at the time of cutting, but in case it should be omitted they should be located as follows: back, 2 in. below shoulder seam; front, ¾ in. up from scye level in front.



25. DETAILS OF CUTTING OUT AND MAKING

Putting in the Sleeve. Start fulness at 1 [**25f**], which is about 1 in. from shoulder seam, and continue it down to 2; from 2 to 3, plain; then put any fulness there may be in the under side at the bottom of scye 3; keep it rather tight in the neighbourhood of 4, and plain up to 5. The sleeve seam is then pressed open, the facing serged to it, and the sleeve lining felled. The remaining touches are pressing, buttonholing, buttoning, etc.—which we have already described—and the garment is finished. This gives the outline of making a lounge jacket, and the principle is similar for other garments.

When there is a waist seam, the fulness is started just in front of the under-arm seam and continued for about 3 or 4 in. in front. When silk facings are put on the fronts of frock or dress coats, it is usual to omit the cloth facing from the under part and merely put on a lining of domet, the facing only extending underneath the silk far enough to make a neat finish.

When garments are made up on the "sub-division" principle, they are usually fitted up with great care, and nearly every part is sewn by machine; thus the outside collar is sewn on to the facings and linings, the inside collar to the back and the fore part; then all is joined up round the edge, and, after the edges have been pared, it is turned out of the armhole.

Continued

THE PARAFFINS & ALCOHOLS

The Paraffins and their Derivatives. Varieties of Alcoholic Fermentation. The Sources and Uses of Alcohol

By Dr. C. W. SALEEBY

Ethane. After methane we have to study ethane, which is the next simplest compound of carbon and hydrogen. This already illustrates for us the remarkable power which carbon possesses of combining with itself. The formula of ethane is C_2H_6. This empirical formula, however, tells us nothing as to its constitution. It can be obtained from a product of methane by a method which we have not space to consider, but it consists of two groups of atoms which have the formula CH_3. This group, or radicle—radicle, of course, means a little root—is known as *methyl*, and ethane may therefore be called dimethyl, since it consists of two methyl groups. Instead of using the empirical formula we may write what is called a constitutional or rational formula, in a fashion which clearly expresses the constitution of the molecule—thus:

$$H_3C\,CH_3.$$

Evidently this expresses much more than the mere empirical formula, nor is there any need for us to take the matter a stage further and use up space in figuring the graphic formula, since the reader can construct or imagine this for himself. He will then notice an illustration of the remarkable fact that one carbon atom can combine directly with another within the molecule.

The Paraffins. Ethane is a colourless, odourless gas resembling methane, and burning with similar products. From it there can be produced, in a fashion similar to that which led to its own production, another body having a similar type of constitution. In fact, there is a whole series, probably an endless series, of such hydrocarbons that have been produced by synthesis, and that are one and all models upon methane. The first four members of the series are colourless gases; subsequent members are colourless liquids; and higher members still are white solids. These bodies are remarkably free from tendency to chemical action. They have no tendency to combine with other elements. The ordinary oxidising agents do not affect them, and thus, since they are almost without affinity, they are known as the paraffins. The following is a list of the first few members of this series:

Methane, CH_4	Hexane, C_6H_{14}
Ethane, C_2H_6	Heptane, C_7H_{16}
Propane, C_3H_8	Octane, C_8H_{18}
Butane, C_4H_{10}	Nonane, C_9H_{20}
Pentane, C_5H_{12}	Decane, $C_{10}H_{22}$

etc., etc.

This extremely instructive series teaches us various things. It gives us a hint of the systematic character of the compounds we are now studying. Its higher members illustrate in an extraordinary way the power possessed by carbon of combining with itself. We observe in this homologous series, as it is called, that the difference between any two successive members is always CH_2. Further, we notice that there is a constant ratio between the number of hydrogen atoms and the number of carbon atoms. The former are always twice the number of the latter plus 2. Hence we can make a general formula for the whole series of paraffins, using the letter "n" to indicate the number of carbon and hydrogen atoms. This formula evidently will be

$$C_nH_{2n+2}.$$

Our study of the composition of the paraffins will suffice to explain why the higher members of this series are so extremely valuable as sources of light, heat, or other forms of energy. Obviously the whole of their substance is oxidisable; they contain no oxygen whatever, in the first place; and they contain an extremely high proportion of hydrogen, which is the most effective of all fuels.

Products of the Paraffins. We must now embark upon a long voyage in order to make the acquaintance of a whole host of important compounds which are derived from the paraffins. But we shall not encounter any very great difficulties if we keep the graphic formula of methane clearly in our heads. It really contains the key to all that is to follow.

The Paraffins and the Halogens. Among the simplest derivatives of the paraffins are those in which atoms of the halogens are substituted for atoms of hydrogen. Of these we have already seen several examples. Now we have to learn that the paraffins agree with one another, not only in the fundamental characters of their architecture, but also in the manner in which they form compounds. Thus, where methane forms compounds, ethane does so likewise. For instance, it is easy to obtain from methane a body which is, so to speak, a hydroxide. One of the hydrogen atoms of the methane has been replaced by the hydroxyl group, giving us the body with the formula CH_3OH. This may be called methyl hydroxide. And if it were a hydroxide we should expect that when it is treated with an acid there should be formed a salt and water, just for all the world as if the hydrocarbon were a metal. This is what happens, and we find that just as sodium hydroxide and hydrochloric acid yield sodium chloride and water, similarly methyl hydroxide and hydrochloric acid yield methyl chloride and water. If we merely remind the reader that methyl chloride has the formula CH_3Cl he will be able to write for himself the equation representing this action. Methyl chloride may also be produced by the action

of chlorine on methane when a mixture of them is exposed to light.

Now we find that ethane behaves in precisely the same way. The direct action of chlorine upon it converts it into chlorethane or ethylchloride, which has the formula C_2H_5Cl. And when the hydroxide of ethyl is treated with hydrochloric acid, the same substance is similarly produced. In this last sentence we have casually referred to one of the most important substances in the whole world, which we must discuss at length hereafter, and which is commonly known as *alcohol.*

The Alcohols. If we conceive of the paraffins as similar to metals, we are prepared to understand their possession of hydroxides. Each of them has its own hydroxide, one atom of hydrogen having been replaced by one hydroxyl group. These hydroxides are called alcohols, and therefore the first fact which we have to learn is that, properly speaking, alcohol is a general chemical term for a very large number of compounds. Just as there are lower and higher paraffins, so there are lower and higher hydroxides of the paraffins, or lower and higher alcohols. The first alcohol is, of course, methyl hydroxide or methyl alcohol; the second is ethyl hydroxide or ethyl alcohol; and it is this which is of such importance to man. The alcohol derived from propane is, of course, propyl alcohol. That derived from pentane is usually known as amyl alcohol, and has, of course, the formula $C_5H_{11}OH$. The presence of this and other higher alcohols in alcoholic drinks is of the utmost practical importance, since it leads to very serious symptoms in consequence of the rapidly poisonous and deliriant action which certain of these bodies possess. Methyl alcohol is of comparatively small importance. When we come to consider the next set of derivatives of the paraffins we shall see, however, that a substance derived from it is of great interest in relation to certain of the fundamental facts of life. Meanwhile, however, we must consider the alcohols.

Preparation of Alcohols. If we desire to prepare an alcohol, we find that it may be obtained from the corresponding halide, just as sodium hydroxide may be obtained from sodium chloride. For instance, water, under certain conditions, reacts with ethyl iodide, the hydroxyl of the water takes the place of the iodine atom, with the result that ethyl alcohol and hydriodic acid are formed. The equation for this is as follows:

$$C_2H_5I + HOH = C_2H_5OH + HI$$

There are many other fashions in which alcohols may be obtained, but we may content ourselves with afterwards discussing the method of Nature, which depends upon fermentation.

There are various kinds of alcohols, which are called *primary, secondary,* and *tertiary,* but their particular characters need not be discussed, nor yet the details of their derivation. The alcohols in general display a sequence of characters, as might be expected from analogy with the paraffins. Sir William Ramsay says: "The lower members of the series are mobile, colourless liquids, with but faint alcoholic smell, and mix with water in all proportions. The middle members are oily and have a heavier smell, and are sparingly miscible with water; and the higher members are insoluble, colourless, crystalline solids. The tertiary alcohols melt at a much higher temperature than do the primary and secondary."

Wood Spirit. The common name by which methyl alcohol is known is *wood spirit,* since it is obtained by the distillation of wood. This, however, yields many other products, such as water, vinegar, creosote, and tarry matter. In order to obtain it separately, calcium carbonate is added to this mixture, so as to combine with the vinegar; then when it is distilled, methyl alcohol and water are obtained. It boils at about 66° C. It is extremely inflammable, and is used as a source of heat, and, like ethyl alcohol, as a solvent, especially for gums, indiarubber, etc. When methyl alcohol is oxidised it follows the rule which, as we shall see, obtains generally of the series to which it belongs, and yields an acid. This is formic acid.

Methylated Spirit. This familiar product consists of a mixture of ethyl alcohol with 10 per cent. of methyl alcohol. The idea is to obtain a substance having the essential properties of ethyl alcohol but so disagreeable to the palate that it would not be drunk. This substance is now about fifty years old, and, needless to say, has been very largely used for the purposes for which it was intended—as a solvent, as a preservative, as a source of light, and so on. It is the lamentable fact, however, that, despite its disagreeable character, it has not infrequently been employed for the purpose of producing intoxication. It should really be made decidedly more disagreeable than it is. The common form of methylated spirit contains a good deal of petroleum oil as an impurity.

This, however, is the time at which one cannot too strongly insist that the device of preparing methylated spirit is totally inadequate to meet the present needs of this country. Probably the most productive and valuable of all the uses of ethyl alcohol depend upon its purity or comparative purity. The consequence is that the manufacturer in this country is ridiculously handicapped: he has to pay shillings where his German rival pays pence, and the consequence is that the manufacture of drugs, perfumes, etc., is handicapped in this country to the point of extinction. It is high time that we really had scientific taxation which would prevent us from strangling our industries in the process of collecting money for the purposes of revenue. Methylated spirit does not meet all the needs, and it is absolutely necessary that ethyl alcohol should be obtainable for manufacturing purposes without the payment of the heavy duty which is rightly placed upon it when it is used or abused in order to please the palate and nervous system.

Ethyl Alcohol. The formula of ethyl alcohol may be written in many ways, each of them varying in the amount of information which it affords. The empirical formula is C_2H_6O. While this correctly indicates the number and character of the atoms in the molecule, it really tells us nothing as to the manner in which they are built up. The formula C_2H_5OH is much superior, since it indicates that the substance is a hydroxide; but the formula CH_3CH_2OH is better still, since it indicates the structure of the molecule in still more detail. Indeed, we have only to transpose the first and second terms in order to have the means of constructing the graphic formula of ethyl alcohol completely before us.

Fermentation. Fermentation is, of course, a very large term, indicating a whole host of actions. In general, we mean by a ferment a substance which has the power of inducing chemical change in other bodies without undergoing any change itself. Here we cannot discuss the problems which it involves, but must merely consider the facts of the commonest kind of fermentation, which is alcoholic fermentation. This process has long been known. The first age at which man prepared alcohol is far earlier than any recorded history. We know for certain that wine and beer were offered to the dead in Egypt in the fourth millennium before Christ, and there is other conclusive evidence to show that wine was prepared earlier than the fifth millennium before Christ. But it is only within a few decades that we have learnt the most remarkable and significant fact, which has led to such great consequences. It is that the ferment of alcohol is a living thing. This, as everyone knows nowadays, is the yeast plant or the sugar mould, or, as the technical name goes, the *saccharomyces cerevisiæ*. It also has a shorter name—*torula*. It consists of tiny rounded cells which multiply by the process of forming buds—the process known as *gemmation*. This they do when they live in sugary fluids, and their multiplication depends upon a change which they produce in the sugar. During the fermentation of the sugar the yeast multiplies rapidly, and forms a scum on the surface of the fermenting fluid. There are definite limits of temperature within which the process can occur, and there is also a point at which the production of alcohol arrests the fermentative process by interfering with the life of the yeast plant. The historic discovery that alcoholic fermentation is caused by a living creature is an important link in that great chain of discoveries which led to the similar discovery of living microbes as the causes of fermentation, inflammation, and putrefaction in the body—thus leading to antiseptic surgery and its magnificent consequences, which have enabled a writer with a nice sense of antithesis to say that Lord Lister "saves more lives every year than Napoleon took in all his wars."

The yeast plant is found practically everywhere. We thus take it in large quantities with our food; but it is rapidly killed by the healthy stomach, which produces that powerful antiseptic, hydrochloric acid. In cases of indigestion, where the production of this acid is defective, the yeast plant is enabled to multiply and cause alcoholic fermentation of the sugar of the food. This, of course, deprives the sugar of its food value and produces a quantity of gas, which causes discomfort and tends to stretch the walls of an already over-stretched stomach.

If a solution of sugar be exposed to the air—and the same is true, of course, of jam and many other substances containing sugar—specimens of these plants soon drop upon it from the atmosphere and undergo development. The essential change of alcoholic fermentation is the formation of ethyl alcohol and carbon dioxide from grape sugar. This body is a carbohydrate and has the formula $C_6H_{12}O_6$. The reader should write out, for practice, an equation representing the decomposition. He will find that one molecule of grape sugar yields two molecules of ethyl alcohol and two molecules of carbon dioxide.

Sources of Grape Sugar. The technical name for grape sugar is *glucose*. It is by far the most important of all the carbohydrates, since it is the subject of alcoholic fermentation, and since it represents the form in which all carbohydrate foods are utilised by the animal body. It is the characteristic sugar of grapes and, indeed, of fruits in general. But it is also obtained indirectly by transformation of other sugars. There is, for instance, another sugar with which we are most familiar, called *cane sugar*. This has to be changed into glucose—involving, as we shall see later, merely the insertion of a little more water into its molecule—before it can undergo alcoholic fermentation. It is the sugar of molasses. From fruits we obtain such alcoholic liquors as wines and brandy, while from molasses we obtain rum. But there is yet another carbohydrate which is a very important source of glucose, and that is starch. This is abundantly contained in such vegetables as potatoes and barley. It has the empirical formula $C_6H_{10}O_5$, being thus not very remote from grape sugar in constitution. A ferment called *diastase* has the power of converting starch into grape sugar, and various alcoholic drinks are thus prepared, such as whisky, beer, and porter.

Alcohol and Bread. It will have occurred to the reader that surely alcohol must be produced in the making of bread, since all the necessary materials are present; and this is so. Indeed, bread owes its rising to alcoholic fermentation, since it is the carbon dioxide thus produced that gives the bread its characteristic texture. The whole, or practically the whole, of the alcohol produced evaporates and is lost. Extraordinary calculations have been made as to the monetary value of the alcohol which is thus produced and lost in the course of the manufacture of bread. In the making of so-called "aerated bread" yeast is not employed, and the carbon dioxide which is necessary in order to give the bread lightness is forced into it from without.

Making Wine. The principle of the manufacture of wine is simply to induce fermentation in the juice of the grape. The necessary yeast plant can be abundantly obtained from the skins of the grapes themselves. The process of fermentation has its own natural limit, and thereafter the product is run into casks. In the case of effervescing wines the bottling is done before the process of fermentation has ceased. When the pressure of the cork is removed, the carbon dioxide which has accumulated in the course of fermentation after the process of bottling is permitted to escape. The following statement of the strength of various wines is compiled from the table of Roscoe:

Port (old bottled) ..	20·2 per cent.
Port (newly bottled) ..	17·4 „
Montilla sherry (1854) ..	16·3
Fine Marsala	17·0
Madeira	16·1
Beaune	13·5
Various hocks ..	9·4 to 8·7
Bordeaux ..	6·4 to 8·7

These estimates, of course, do not begin to account for the differences in flavour displayed by various wines. These are due in the main to the presence of chemical bodies of great variety which are known as ethers or compound ethers, and which we must discuss later. These are very volatile fluids, which, in the majority of cases, have a very agreeable odour. They are mainly formed by the action of acids upon alcohol.

Other Constituents of Wine. We have to recognise the acids of wines, therefore, as very important. These may be at least seven in number, most of them being organic acids. They occur largely in combination with various metals, such as potassium, sodium, calcium, magnesium, and iron. The free acidity of wines, reckoned as tartaric acid, varies from 0·2 per cent. in the best wines to as much as 0·7 per cent. in inferior wines. More than 1 per cent. of free acid makes the wine practically undrinkable. The proportion of acidity in a large number of good wines of various kinds, as stated in a well-known German table, varies within only very small limits.

There are so-called wines which are not wines at all; there is no real trace of the vine in them. Other wines are only in part derived from the grape. Many wines have alcohol added to them from without, and many more have ethers artificially added to them in order to produce cheap imitations of other wines. Many wines, especially French, Spanish, and Italian, are plastered—that is to say, have calcium sulphate added to them. The consequence is the production of tartrate of calcium, which is precipitated. In such wines the acidity is represented only by an acid called *malic acid* and not by tartaric acid at all.

A complete analysis of wines shows that their nutritive value is practically nil, except for the sugar contained in sweet wines. There is, of course, no reasonable proportion whatever between the nutritive value of wines and their cost.

The distillation of wines produces brandy. This contains a large number of ethers and from 35 to 45 per cent. of ethyl alcohol.

Spirits. Besides brandy, made from the grape, we have to consider rum made from molasses, which is the residue that cannot be crystallised after as much cane sugar as possible has been crystallised from the juice of the sugar cane. The molasses are dissolved in water, yeast is added, and after fermentation, the product is distilled. The characteristic ether of rum is called *butylic ether*, and this spirit contains from 50 to 70 per cent. of ethyl alcohol. Whisky is obtained by distillation of beer. It contains from 50 to 60 per cent. of ethyl alcohol. The raw product contains a number of highly objectionable and poisonous substances, especially fusel oil and furfurol. Besides those we have mentioned we may note various other spirits—absolute alcohol, which contains nothing but alcohol except for about ½ per cent. of water; rectified spirit, which is 90 per cent. absolute alcohol; proof spirit, which contains 49·3 per cent. by weight of pure alcohol and 57·09 per cent. by volume. For Excise purposes the strength of alcohol in solutions is always estimated and stated by comparison with proof spirit. "Twenty-five over proof" describes a spirit which is such that 100 volumes of it diluted with twenty-five volumes of water will be equivalent to proof spirit. "Twenty-five under proof" means that 100 volumes of the spirit so described contain seventy-five of proof spirit. Next comes Geneva or Hollands, which contains from 50 to 60 per cent. of alcohol, and is flavoured with oil of juniper. On this ground it is supposed by ignorant persons to be of value in disease of the kidneys; but as a matter of fact both the alcohol and juniper are deleterious in such cases.

German Spirit. Many other spirits can be obtained from vegetable sources; arrack, for instance, is obtained from coconut or palm juice, and Japanese spirit from rice. Much more important, however, is German spirit, which is obtained from the potato, in consequence of the following facts. Any kind of starch when boiled with dilute sulphuric acid is changed into grape sugar. The acid acts as a ferment since it is not itself changed. The addition of lime to the mixture separates the sulphuric acid by the precipitation of the insoluble sulphate of lime, and the glucose is left in solution. It can then be used for the manufacture of alcohol. In thoroughly characteristic fashion the Germans have discovered, first of all, how to manure unpromising soil so that it shall yield abundant potatoes; secondly, how to obtain sugar and then alcohol from these; and thirdly, how to obtain a market for the potato spirit which results. It was lately estimated that we pay the Germans £1,600,000 per annum for such spirit. There is, of course, no reason in the world but our carelessness of science to prevent us from producing any quantity of this valuable spirit at home.

Beer. The chief source of beer is barley. When the barley grain is moistened with water and exposed to the atmosphere it begins to

germinate, while its starch is largely converted into grape sugar, as we have already seen. The reader will write for himself the equation representing this change. A constant temperature has to be maintained, and the consequence is that all the starch originally present in the grain appears in solution as grape sugar. The temperature is then suddenly raised, and the young shoots of barley are killed. The grain in this state is known as malt. After various further processes, fermentation is induced, and after four or five days beer results. Beer conspicuously differs from wine and other alcoholic liquors in having a small nutritive value. This has been very much overrated in the past and, in any case, the proportion of its nutritive value to its cost is ridiculously low. The proportion of alcohol in various beers varies. Burton ale contains nearly 6 per cent., and Edinburgh ale the same amount. London porter varies a good deal, from about 5·4 to 6·9 per cent. Lager beer, despite the general opinion that it contains very much less alcohol, contains 5·1 per cent. There are various German beers, however, which contain as little as 2 per cent. The German beers contain a comparatively small quantity of the chemical bodies which are grouped as *extractives*, and this is an advantage, since these bodies are difficult of digestion. The other important constituents of beer are, on the average, as follows: Water, 90 per cent.; various organic acids, 0·1 to 0·3 per cent.; sugars, 4½ to 5½ per cent. Quite an appreciable quantity of albumen also occurs in beer, but what nutritive value it has depends mainly upon its sugar.

The hops used in brewing are mainly valued for their flavour. Their only bearing on the chemistry of the subject is that they tend to check the further fermentation called *acetous*.

Other Alcoholic Liquors. There are many liqueurs which are compounded from alcohol and aromatic essences. Some are sweet and others, such as vermouth, are bitter. There are two alcoholic products obtained from animal sources, the ancient *mead*, which is obtained by the fermentation of honey, and the very valuable product *koumiss*, which is obtained by the fermentation of mare's milk, and which is often tolerated by the stomach of the invalid when nothing else is of any avail. The alcoholic fermentation of apples yields cider, which contains a good deal of sugar and, as a rule, by no means so little alcohol as is usually thought. In general, a cider is quite as strong as a beer. Perry is a similar drink made from pears.

Alcohol in Drugs. Alcohol is also contained in a very large number of drugs—notably in tinctures, essences, and so on. It has lately been demonstrated that, especially in the United States of America, alcohol is one of the most important ingredients of patent medicines. Certain types of blackguards have discovered that they may line their pockets by increasing the facilities with which women especially may become drunkards. It has been shown that many so-called patent medicines may consist of as much as 45 per cent. of alcohol with a little flavouring matter and nothing else. This is a form of criminal fraud which must surely attract the attention of the law before long. It has played its part in producing that lamentable increase of alcoholism among women, upon which all observers are agreed, and which, if we remember the extreme importance of women in relation to the future, must be recognised as one of the gravest menaces to the continuance of our civilisation.

Characters of Alcohol. Pure waterless or anhydrous alcohol is an inflammable fluid having a specific gravity of 0·806. It has a great affinity for water, and the result of this is that it is almost impossible to obtain it without this impurity, and that alcohol is one of the most powerful dehydrating substances known. In order to remove water from it, as far as possible, many devices have been adopted. The so-called absolute alcohol of commerce, which, as we have seen, is not really absolute, is obtained by the use of caustic lime or calcium oxide, CaO. Small pieces of caustic lime are placed in spirits of wine in a retort, and after a few hours the alcohol can be distilled off, the lime having been slaked or converted into calcium hydrate. Absolute alcohol is very mobile and refractive. It has scarcely any appreciable taste or smell, though of course it stimulates the nerves of common sensation in the mouth and so, by an abuse of language, it is described as having a burning taste. This so-called taste is really due mainly, if not entirely, to the rapid abstraction of water from the tissues with which the alcohol comes into contact. Alcohol does not conduct electricity. At a temperature of about 100° C. below zero it becomes viscous. In the article "Alcohol" in the "Encyclopædia Britannica," written now thirty years ago, it is stated that alcohol has never been frozen. But that has since been accomplished at a temperature of 130° C. below zero. The fluidity of this substance at low temperatures and its high coefficient of expansion [see PHYSICS] make it very valuable for use in thermometers.

Alcohol and Water. The fondness of alcohol for water is so great that we begin to suspect that some chemical action must be involved. This suspicion becomes practically a certainty when we discover that the dilution of alcohol with water causes the evolution of much heat, and also, that up to a certain point the mixture of water and alcohol causes a reduction of the volume occupied by the two. No doubt there is some chemical action involved, and the satisfaction, or transformation of chemical potential energy, is expressed by the appearance of that form of kinetic energy which we call *heat*—just as the burning of coal produces heat. Sulphuric acid and water behave similarly.

These and many other instances make it plain that, as usual, we find some reservation necessary when we come to look more closely into the question of the dogmatic distinction between compounds and mixtures. The distinction is a real one, but Nature is continuous, and, as everywhere else, we find, if we look carefully enough, gradations between all her various processes.

Continued

RESERVES & SINKING FUNDS

Doubtful Debts. Outstanding Liabilities. Suspense Accounts. General and Special Reserves. Investment of Fund. Secret Reserves

Continued from page 2750

By J. F. G. PRICE

IT has been assumed hitherto that all the expences of the business of Smith & Jones are included in the trial balance shown on page 2502, and that as they have been taken into consideration in making up the profit and loss account, we have arrived at the correct amount of the net profit of the concern. It was, however, pointed out that the proprietor of a business with fixed assets must make allowance for decreases in their values, as shown in his books on account of the depreciation that is continually going on by reason of wear and tear. It will be seen from the balance-sheet already given that there are no fixed assets belonging to the business of Smith & Jones, and there is, therefore, no necessity to make allowance for depreciation, as the stock has been carefully taken and valued at not more than cost.

Book Debts. But there is an asset which requires examination before a definite statement can be made that all proper losses and expenses have been charged in the profit and loss account. That is the item of "Sundry Debtors," which in ordinary circumstances would have to be studied in detail in order that a conclusion might be formed as to whether any of the debtors are likely to fail to meet their obligations. In the present case the debtors are only three in number and the examination is a simple matter. In large undertakings, however, where there may be hundreds or thousands of debtors, the scrutiny of all the accounts and their consideration by the manager or proprietor would be a work of much labour and, even if carried out conscientiously, would probably end in a misleading result being obtained.

Reserve for Doubtful Debts. Another method is therefore adopted in order that proper provision may be made for the probability that some of the debtors will not pay the amount due from them. We have seen how a trader deals with an ascertained loss under this head by writing off the amount to the profit and loss account through a sub-account known as the Bad Debts Account. Past experience has told him that a certain proportion of his debtors fail to pay, and that although he has debts on his books amounting to £2,000, he cannot expect to receive every penny of that amount. An examination of his books for past years shows that the bad debts actually incurred and written off form a percentage at a fairly constant rate of the debts outstanding at the time of the last balance-sheet; and upon the figures of several years he is in a position to form an opinion as to how much should be allowed for probable loss on the debts now owing. He cannot point to any particular account as being bad; if he could he would at once write it off as a loss. But although he cannot do this, he knows that somewhere there are debtors who, from a variety of causes, will not discharge their indebtedness. To meet this contingency he decides to reserve an amount out of his apparent profits, and an allowance of what is deemed sufficient is accordingly made and debited to the profit and loss account. But the question then arises: Which account is to be credited? It would be both impracticable and incorrect to credit each debtor with a proportion.

Opening the Reserve Account. An account is therefore specially opened which is credited by the amount it has been decided to reserve. This account is generally entitled "Reserve for Bad and Doubtful Debts," and, as a rule, it is allowed to stand in the ledger as a credit balance throughout the year; bad debts which are definitely ascertained in the meantime being debited to the bad debts account. At the time of balancing the books the debit balance on the bad debts account is transferred to the reserve account, and a calculation is made to provide a fresh reserve against the debts now outstanding. In doing this, regard must be paid to any balance remaining on the reserve account after charging the bad debts, or for any excess of bad debts over the reserve set aside the previous year. These two contingencies are best illustrated by examples.

On 31st December, 1903, William Brown had book debts due to him amounting to £5,000, and he decided to make a reserve of 5 per cent. on that amount to meet possible losses. On 31st December, 1904, he found that his bad debts actually incurred during the year amounted to £200, while he had now book debts of the value of £5,500. He decided to set aside a reserve of 5 per cent. on this amount. During 1905 his losses by bad debts came to £300, while on 31st December of that year his debts outstanding were £6,000. He decided to make a reserve at the same rate as in the two previous years. The table given on the following page would be his reserve account.

A reserve of a similar nature is sometimes made for discounts which will have to be allowed to debtors. The process is exactly the same as in the case of bad debts, and need not therefore be explained in detail. The amount standing to the credit of the reserve account would, in the absence of special circumstances, be shown on the liabilities side of the balance-sheet, but it is the practice not to show a reserve for a specific purpose in this way but to deduct it from the particular asset in respect of which it has been created. For this reason

Dr.	RESERVE FOR BAD AND DOUBTFUL DEBTS				Cr.
1904 Dec. 31	To transfer from bad debts account	200 0 0	1903 Dec. 31	By profit and loss account (5% on £5,000)	250 0 0
			1904 Dec. 31	„ Do. (5% on £5,500) 275 Less Unexhausted balance 50	225 0 0
	„ Balance carried down..	275 0 0			
		475 0 0			475 0 0
1905 Dec. 31	„ Transfer from bad debts account	300 0 0	1905 Jan. 1	By Balance .. .. b/d	275 0 0
			Dec. 31	„ Profit and loss account (Excess of loss over reserve)	25 0 0
				„ Do. (5% on £6,000) ..	300 0 0
	„ Balance .. .. c/d	300 0 0			
		600 0 0			600 0 0
			1906 Jan. 1	By balance.. .. .. b/d	300 0 0

reserves for bad debts and discounts are deducted from the amount of the sundry debtors.

Outstanding Liabilities. There is yet a further point to be borne in mind in making up a profit and loss account. The books record only the transactions which have taken place, and we should find nothing in them of liabilities which become due automatically, such as rent, rates and taxes, until payments in respect of these matters were actually made. It is, therefore, very necessary at balancing time to make sure that all outstanding charges which affect the profit and loss account are taken into consideration before arriving at the final balance available for the proprietor. The majority of business houses have their books made up to the end of the months of March, June, September, or December; and it may safely be asserted that there is something unpaid in the nature of expenses, the liability for which has not yet been recorded.

An instance that immediately presents itself is rent, which becomes due on the usual quarter days, but which is frequently not paid for two or three weeks. The result would be that a trader making up his books to December 31st would find charged in his rent account only the amounts paid for Lady-Day, Midsummer, and Michaelmas quarters.

Taxes and Wages. Similarly, taxes are not payable until January 1st in each year; but as they cover the period from April 6th in one year to April 5th in the next, it is clear that any profit and loss account covering a year to December 31st must make allowance for the proportion of the charge falling against that year. The same considerations apply to rates which are either accruing or overdue but unpaid.

In a large manufacturing concern another item of considerable importance is wages. There are many undertakings in which the weekly wages bill considerably exceeds £1,000. The wages are made up to either Thursday or Friday evening and paid on the latter day or on Saturday. But if December 31st falls on Wednesday, the wages for the previous four or five days which have become due, and may amount to £1,000, are not recorded in the books, and must be taken into account in arriving at the true profits of the business for the period to December 31st.

Suspense Accounts. In order to bring these matters into the books the amounts outstanding are, if necessary, apportioned between the period for which the accounts are being prepared and the remainder of the time covered by the expense, whatever it may be, and a charge made in the profit and loss account in respect of the liability. In this case, as in that of the reserve for bad debts, it is not possible to credit each workman or rate collector with the amount due to him, so an account is opened and credited with the apportioned amount of the expenses. This account is shown on the liabilities side of the balance-sheet and is extinguished in the books as payments are made in the following period by being debited with the amounts so paid.

Payments in Advance. It sometimes happens that payments have been made during a financial year, part of which are properly chargeable against the following period. For example, insurance is usually paid once a year. In a large factory, fire and employers' liability insurance are not inconsiderable items, and if they are paid on September 29th by a manufacturer who has his accounts made up to December 31st, the year to the latter date will be bearing an unfair share of the burden if an adjustment is not made by which the following year will be made to bear that part of the expense of which it receives the benefit. In order to correct this a part of the expenditure—in the case above instanced, three-quarters of the premiums—will be carried forward on the debit side of an "Insurance Suspense Account," and will appear on the balance-sheet on the assets side under the head of "Insurance paid in advance." Likewise, any rates or other charges, part of which belong to the following year, should be apportioned and carried forward.

Reserve Fund. The reserve and suspense accounts explained so far have been in respect of specific matters outstanding at the time of balancing the books, which must be taken into consideration in arriving at the amount of the true net profit. There is, however, a reserve of a different nature which is

frequently seen in the balance-sheets of undertakings, principally limited companies. It is generally termed a *reserve fund*, and its treatment has afforded a fruitful theme for discussion among accountants. The great difference between the account representing the reserve fund and the kind of reserve account already dealt with is that it was necessary to create the latter by a charge against the profit and loss account, in order to ascertain the actual divisible profit available for the proprietors, while the former is brought into existence after that result has been obtained, and is, in fact, a part of the net profits. This difference is vital and the position may be summed up by saying that the reserve accounts in respect of specific assets are created to meet losses and expenses which it is known will be incurred in the future, while the reserve fund is a setting aside of net profits to meet possible losses of which the proprietor has no knowledge at the time but which, it is conceivable, may arise. The reserve fund usually found in balance-sheets is what is known as a *general reserve*—that is, it has been set aside out of profits, not for a specific purpose, but generally to meet contingencies. In the vast majority of cases there is no special investment of the fund, and care is seldom taken even to ensure that there are liquid assets readily available in case of necessity.

Investment of Reserve Fund. There is considerable difference of opinion whether a reserve fund, in order to deserve that name, should be separately invested and represented by specific assets, or if it is sufficient to merely make a book entry debiting the net profit and crediting a reserve fund account. The decision depends to some extent upon the nature of the business. In the case of banks, insurance companies, and similar undertakings, where a reserve fund is created largely for the purpose of meeting any shrinkage of value in the securities forming a considerable proportion of the assets, the desirability of specially investing the reserve is generally conceded; in trading concerns, however, other considerations apply, and the question is one that must be decided by the proprietors, having regard to the requirements of the particular business. One cause which is held to justify the non-investment of the fund is that the undertaking requires more working capital than would be left in the business if the profits were divided up to the hilt, or taken out of the business and separately invested; while another justification may be said to exist in the case of a business paying 4 or 5 per cent. on borrowed money, where it would be bad policy to invest part of the profits in Consols or other gilt-edged securities paying only 2½ to 3 per cent. Even if the reserve fund be left in the business, it is of course a source of strength, for it represents an excess of assets over liabilities and proprietors' capital; but to be *reserve* in the true sense of the term there should be liquid assets—*i.e.*, assets easily realisable—even if they are used in the business—readily available to meet an emergency.

The Two Views. The two points of view can be brought before the student in a simple manner by means of an illustration.

T. White takes a lease of some business premises for seven years, with the option of renewing for a further seven or fourteen years, and spends £420 upon altering them to suit his requirements. He does not charge this amount to his profit and loss account, for it is not an expense that can be fairly debited against the profits of a single year. If it is to be written off completely, it will be reasonable to spread the expense over the time during which he will occupy the premises. But here another consideration arises. He cannot yet tell whether he will wish to continue his tenancy after the expiration of the first seven years. If he decided to do so, he would still be able to enjoy the benefit of his improvements. The value of the premises will, naturally, be decreasing during the seven years by the ordinary process of wear and tear, but that is merely depreciation, and not the entire loss of the asset. There is, therefore, an element of uncertainty in the matter; and in order to make provision for the possibility of giving up his shop at the expiration of the first term of seven years, he has to devise means so that by the end of that period his books will not show him to be possessed of an asset which may then cease to exist, without providing for such a contingency.

He estimates that at the end of seven years the value of the premises will be reduced by wear and tear and effluxion of time to £280, and it will therefore be necessary to treat as an absolute loss £140 of the outlay. This he does by debiting profit and loss account with £20 depreciation each year and crediting the "Business Premises Account." By this means the premises will stand in the books at their actual value at the end of the time, subject to his deciding to retain possession.

But, as has already been said, he may give them up. In view of this fact he has, during the term of the lease, charged against his net profits such a sum as would equal the book value of the asset by the end of the seven years—*viz.*, £40 per annum. This amount he has carried to the credit of a reserve fund account, and if at the end of the first portion of his lease he surrenders the premises, the accumulated amount will be transferred to the business premises account, and so extinguish the asset in the books by the time it ceases to be valuable. As a result of these entries, the business premises and reserve fund accounts will appear in the books as shown on next page.

Under this method, nothing was done beyond making the book entries. White did not take £40 of his cash each year and invest it in Consols or other securities in order to have an amount available at the end of seven years towards acquiring other premises if he found his present shop unsuitable. But he might have considered such a course desirable, and in that case he would have opened a "Reserve Fund Investment Account," which would be debited each year with the amount invested in the particular

security he decided to purchase, cash being credited, of course, by the amount withdrawn. Dividends or interest accruing due on the investment, would be received in cash, and credited to the profit and loss account. At the end of seven years the investment account would have been debited with £280, and would represent the investment of the reserve fund account, which appears as a credit on the other side of the ledger. If the premises are given up, as assumed above, and the balance on the business premises account written off against the reserve fund account, the balance on the investment account will represent White's asset in place of the premises.

claimed are that exceptional losses, and losses on legitimate trading, may be borne without the profit and loss account of the year in which they are incurred having to suffer the whole loss. The better course is undoubtedly the gradual creation of a strong reserve fund by openly setting aside profits out of which any losses of the nature indicated could be met as occasion arose.

Sinking Funds. A sinking fund is a fund created by setting aside periodically fixed sums of money with the intention that at the end of a given time the instalments shall, with accumulations of interest, amount to a certain sum which will then be required for a specific purpose. The point which distinguishes a sinking fund

Dr. BUSINESS PREMISES ACCOUNT Cr.

1897 Jan. 1	To cash	420	0	0	1897 Dec. 31	By depreciation..	20	0	0
					1898 Dec. 31	,, Do.	20	0	0
					1899 to 1903	,, Do. (5 years)	100	0	0
					1903 Dec. 31	,, Reserve fund account..	280	0	0
		420	0	0			420	0	0

Dr. RESERVE FUND Cr.

1903 Dec. 31	To business premises account, amount transfered				1897 Dec. 31	By profit and loss account	40	0	0
					1898 Dec. 31	,, Do.	40	0	0
		280	0	0	1899 to 1903	,, Do. (5 years)	200	0	0
		280	0	0			280	0	0

Special Reserve. The reserve fund we have dealt with was in respect of a specific matter, and is known as a special reserve. Another example of a special reserve is that for equalising dividends in the case of a limited company where a portion of the net profit is kept in hand in order to be able to pay a fair rate of dividend to the proprietors—the shareholders—even in a bad trading year. This reserve is now not very frequently seen.

Secret Reserve. Another kind of reserve is known as a *secret reserve*. It is so-called from the fact that the balance-sheet does not disclose its existence, nor is there any account representing it in the books. It is created either by excessive charges being made in the profit and loss account for such matters as bad and doubtful debts, or by the overstating of liabilities, or the unnecessary writing down of assets. The practice is favoured by companies of the highest standing, and, while it has its advantages, it also possesses undoubted drawbacks. The very existence of a secret reserve, and the manner of creating it, necessitate the withholding of material facts from the shareholders, while the system opens the door to fraudulent practices on the part of dishonest managers, who are enabled to conceal losses in speculation by writing up values of assets previously written down. The advantages

from a reserve fund is that while the latter may be represented by assets remaining in the business and not specially appropriated to the fund, the former must always consist of cash, or the equivalent of cash, invested outside the business. The usual purposes for which sinking funds are created are (1) to provide for the repayment of borrowed money at the end of a fixed period, and (2) to provide a fund to renew an asset of a wasting nature, such as machinery or a lease.

It has been seen how necessary it is to write down fixed assets in the books to their actual values by charging depreciation on account of wear and tear and other matters ; but in many cases this is not sufficient. Unless provision is made gradually, a manufacturer is faced with the situation that his machinery is worn out and must be replaced, and although he has allowed for depreciation yearly before arriving at his profits, he has taken no steps to accumulate a fund out of which he could purchase new machinery. His capital is all locked up in his business, and cannot be withdrawn without damage. In order to obviate this difficulty it would be necessary for him to create a sinking fund, so that when the old machinery is unusable he can arrange for the installation of a new set without financially dislocating his business.

Borrowed Money. The repayment of borrowed money is a factor which has to be provided for by a limited company which has issued debentures. The characteristics of debentures will be explained later, when dealing with the accounts of limited companies, and as the student may not be aware of the different circumstances under which they are issued, the case of a sinking fund to replace a specific asset will be dealt with now rather than one relating to debentures.

The first step to take is to decide, either by calculation or by reference to published tables, the amount necessary to be set aside and invested each year, so that, allowing for interest on the investment at a certain rate, the sum 'accumulated' will reach the amount required by the time it is needed. Having fixed the amount, the process is the same, with one exception, as that adopted with regard to the investment of the reserve fund. The one exception is that interest on the investment, instead of being credited to profit and loss account, is added to the amount of the investment, which is therefore accumulating at compound interest during the building up of the fund.

Sinking Fund for Wasting Asset. We will suppose that a system of machinery has been installed in a factory at a cost of £5,000, and that it is anticipated that its working power will be exhausted, notwithstanding repairs in the meantime, at the end of 20 years. It is intended that the business shall be continued after that time, and it will therefore be necessary to put in a new lot of machinery when the old is worn out. In the ordinary course of events there will not be a surplus of £5,000 in the bank above the current requirements of the business, and the proprietor decides to raise a fund during the life of the present machinery out of which the new machinery can be purchased when it is required. It is found that the amount required to be set aside each year in order to do this, after allowing for accumulations of interest in the meantime at 3 per cent., is £186 1s. 7d.

The entries necessary in the books will be, first, a debit to profit and loss account, and a credit to the machinery account, of the instalment. A corresponding amount of cash will then be taken from the bank and invested in the purchase of the stock chosen for the purpose of the sinking fund investment. This will necessitate a debit to the sinking fund investment account and a credit to the bank.

Dr. SINKING FUND INVESTMENT ACCOUNT FOR MACHINERY Cr.

Date	Particulars	£	s.	d.	Date	Particulars	£	s.	d.
1900 Dec. 31	To cash	186	1	7					
1901 Dec. 31	,, Interest (1 year @ 3 %)	5	11	7					
,,	,, Cash	186	1	7					
		377	14	9					
1902 Dec. 31	,, Interest (1 year @ 3%)	11	6	7					
,,	,, Cash	186	1	7					
		575	2	11					
1903 Dec. 31	,, Interest (1 year @ 3%)	17	5	1					

Dr. MACHINERY ACCOUNT Cr.

Date	Particulars	£	s.	d.	Date	Particulars	£	s.	d.
1900 Jan. 1	To cash	5000	0	0	1900 Dec. 31	By profit and loss account	186	1	7
					1901 Dec. 31	,, Interest on investment	5	11	7
					,,	,, Profit and loss account	186	1	7
							377	14	9
					1902 Dec. 31	,, Interest on investment	11	6	7
					,,	,, Profit and loss account	186	1	7
							575	2	11
					1903 Dec. 31	,, Interest on Investment	17	5	1

At the end of the year, when the interest on the stock has become due, the investment account is debited with the amount, which is allowed to remain, and itself earn interest, while the machinery account is credited. At the same time another instalment of £186 1s. 7d. is taken out of cash and invested, entries being made similar in all respects to those at the beginning. The accompanying tables show the entries on the investment and machinery accounts for the first three years.

This process is continued each year until, at the end of 20 years, the fund has grown to the amount required—*viz.* £5,000. The investment is then sold, and the proceeds used for purchasing the new machinery.

Continued

continued from page 2740

MOVABLE BRIDGES

Ancient Drawbridges. Bascule, Rolling and Swing Bridges. Stresses in Opening Bridges. Draw, Lifting and Pontoon Bridges. Transporter Bridges

By Professor HENRY ADAMS

Need for Opening Bridges. When a navigable waterway passes between steep banks, it is possible to build a fixed bridge high enough for vessels to pass under without lowering their masts, as in several of the cases of large span bridges that have already been mentioned; but there are many more cases where the bridge has to be fixed at so low a level that some portion of it must be made to open, although it is possible to build steamships of 2,000 tons burthen to pass through the small and low arches of an ordinary river bridge; for example, several screw colliers were built to pass up the Thames through the small arches of the old Vauxhall Bridge, where the clearance remaining all round was only measured by inches. An interesting example occurs at Newcastle-on-Tyne, where a noted high-level road bridge crosses between the banks with a railway track above it, and close alongside a low-level bridge connects the lower parts of Gateshead and Newcastle. When the Elswick Works, founded by Lord Armstrong, began to furnish the large ironclads with their powerful armament, it was found that the old low-level fixed bridge prevented the battleships from passing up the Tyne to the Elswick Works to receive their complement of big guns, and a new low-level bridge was erected in 1876, with an opening span, in the form of a swing bridge giving two passages each of 110 ft. clear width, and when closed, forming a roadway 50 ft. wide from shore to shore.

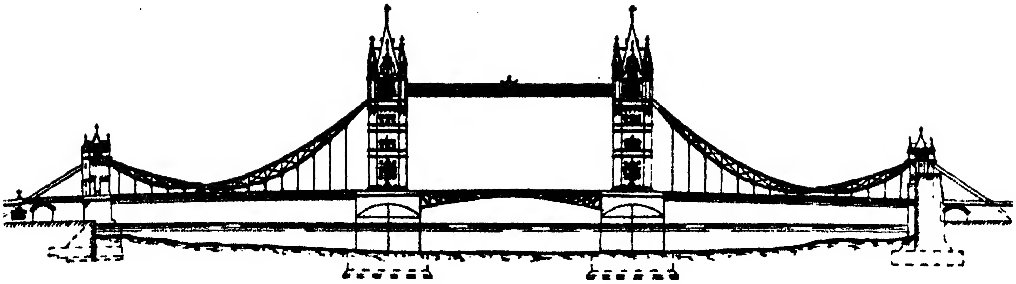
Ancient Drawbridges. There are several different types of movable bridges, the oldest of which is the so-called drawbridge spanning the castle moat of feudal times. This was a planked roadway lifted by chains attached to the outer end, and working on a horizontal shaft near the portcullis of the entrance to the castle. This would now be called a *bascule* bridge, and was the progenitor of various modifications of which the Tower Bridge, over the Thames at London, is the most prominent example.

The Tower Bridge, London. The Tower Bridge [31] is a combination of a bascule bridge with two suspension bridges. It consists of a central span of 200 ft., in two half spans, lifting on axles at the base of the towers, the movement of each being effected by a pinion rotated by a steam engine and working into a quadrant rack attached to the pier end of each leaf. The towers are tied together at the top by a straight footway, and they support on the shore sides two suspended spans of 270 ft. each. The "chains" are, in this case, really braced girders made with a suitable curve in two portions. The towers are essentially steel-framed structures clothed with stonework, for architectural effect. The total height of the towers, measured from the level of the foundations, is 293 ft. For the construction of the bridge, about 235,000 cub. ft. of granite and other stone, 20,000 tons of cement, 70,000 cub. yd. of concrete, 31,000,000 bricks, and 14,000 tons of iron and steel were used.

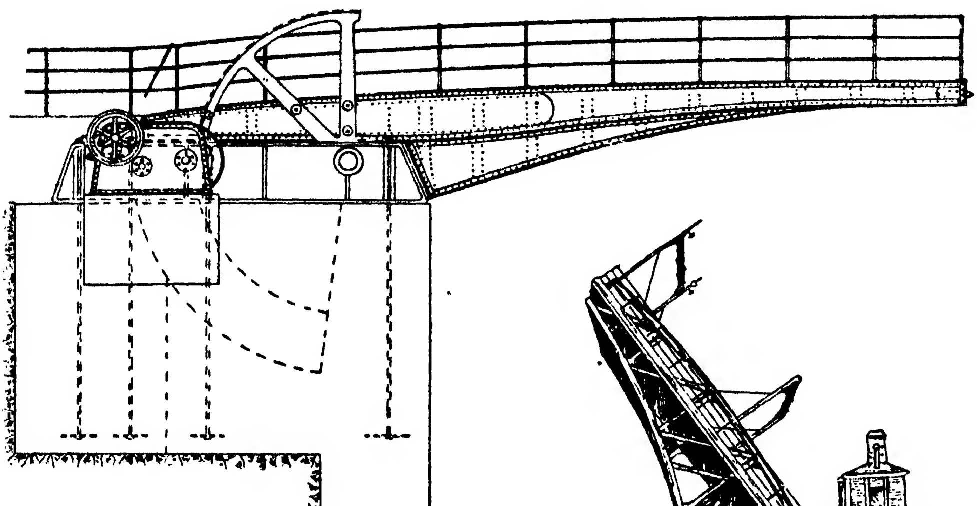
Bascule Bridges. The essential feature of the bascule bridge is the turning upon a horizontal axis as above described, the lifting being seldom effected by chains. Smaller bridges on the same principle have been erected at the Bristol Docks, at Deptford Creek, and elsewhere. One great difficulty bascule bridges have to contend with is the wind, which, while tending to prevent one leaf from being opened, may expedite the opening of the other side to a dangerous degree, unless provision has been made to counteract it. In the case of the Tower Bridge, a wind pressure of 56 lb. per sq. in. was allowed for, and as an average high wind does not reach more than about 22 lb. per sq. in., there is an ample margin for safety. An illustration of a small bascule bridge in leaves of about 60 ft. total span is given in **32**. This is worked by manual power.

Rolling Bridges. A modification of the bascule bridge is found in the rolling bridges, such as the Scherzer Rolling Lift Bridge over the Cuyahoga River, Cleveland, Ohio, of 160 ft. span, double track [33]. A sketch of one leaf of a bridge upon the same principle is shown open in **34**. In this form, a pure rolling motion is substituted for the axle friction of the earlier bascules, and it also has advantages over the more commonly used swing bridge, which requires a free horizontal space equal to its radius in which to swing.

Swing Bridges. A swing bridge is one turning about a vertical axis, and is the usual form of movable bridge over a dock entrance. The earlier swing bridges were worked by hand power, turning upon a central pivot and resting upon rollers after the fashion of a railway turn-table. When the dock entrances were increased in width to suit the larger ships that were built, hand power was insufficient to work the swing bridges, and hydraulic power took its place, the weight to be moved increasing to five or six times the original amount. In order to economise the space required for swinging, the tail end was made short and loaded with kentledge, and various ingenious details were adapted to reduce friction and facilitate the working. The centre pivot became a hydraulic press of sufficient power to lift the whole weight of the bridge off the resting blocks, and a rack was bolted to the tail end into which was geared a pinion worked

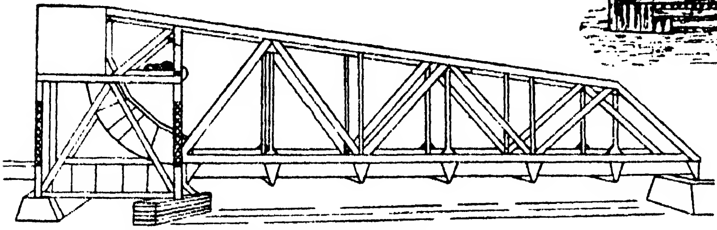


31. *Tower Bridge, London.*

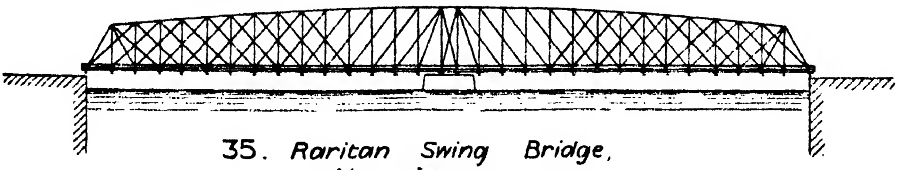


32. *Hand power Bascule Bridge.*

34. *Sketch of a Rolling Bridge*

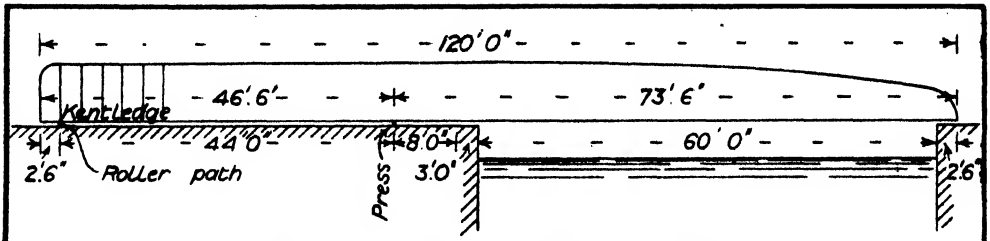


33 *Scherzer Rolling Lift Bridge, Cleveland, Ohio.*

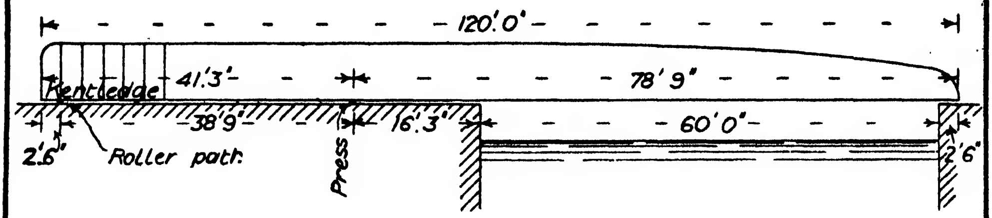


35. *Raritan Swing Bridge, New Jersey.*

SOME MOVABLE BRIDGES



36 Swing bridge without footways.



37. Swing bridge with outside footways

DIAGRAMS OF MOVABLE BRIDGES

by a hydraulic engine actuated by a pressure of 700 lb. per sq. in. An inverted roller path was employed in some cases for the tail end rollers to work upon, so that the bridge should have no chance of tilting into the dock while opening or closing. Some of the hand-power bridges swing in two leaves, to reduce the weight to be moved by each capstan; but when hydraulic power was used, a single leaf was always adopted. The swing bridge carrying the roadway over the 80 ft. entrance of the Millwall Docks, erected under the supervision of the writer as assistant outdoor manager to Lord Armstrong's firm, had a length of 150 ft. and width of 45 ft., and weighed about 500 tons. The largest opening given by a swing bridge appears to be on the Penfeld River, at Brest. The bridge is built in two leaves, each 286 ft. long, and spans a clear waterway of 350 ft. 6 in. The longest swing bridge is one over the Raritan River, New Jersey [35], being double-ended, 472 ft. long, swinging on a central pier, and providing an opening on each side of 216 ft. clear.

Stresses in Opening Bridges. It should be observed that a remarkable duplication of stresses occurs in all movable bridges. When closed they rest upon end supports so that they are in the condition of an ordinary girder supported at the ends with the upper portion in compression and the lower in tension. When, however, the bridge is opened, whether it is a bascule, or swing bridge, or the modern form of drawbridge, it is in the condition of a cantilever and the stresses are reversed. This reversal of stress necessitates a higher factor of safety being allowed, or, what is the same thing, a smaller working intensity of stress, and such bridges are therefore comparatively heavier than fixed bridges of the same span.

Assuming the bridge to be required to span the 60 ft. or 80 ft. entrance lock of a dock basin, the total length of the bridge will average twice the width of entrance; but this depends partly upon the width of the bridge and whether a passage or gangway must be left outside the bridge, when open, for warping the ships in and out of the dock. The centre pivot would be on a hydraulic lifting press, the position being found thus, bearing at nose end 2 ft. 6 in. + width of entrance + gangway (if any) + half width of bridge = distance from point of bridge to centre of press. The radius to centre of tail roller path = centre of press to tail end − 2 ft. 6 in.; the tail end must not be less than half the length of nose end as an extreme difference. The outline of a bridge for a 60 ft. lock, having a roadway only and being 16 ft. wide over all, to leave a 3 ft. gangway when open is shown in **36**, and a similar bridge with a footway on each side making a width of 32 ft. 6 in. over all, and not requiring a gangway left, is shown in **37**.

Drawbridges. Modern drawbridges, or traversing bridges, are pulled back horizontally by powerful machinery placed in a pit below the road level to leave an open waterway; such a bridge was erected under the writer's supervision at the Millwall Docks, London, over the entrance to the inner dock. In place of the central pivot of a swing bridge to lift it off the blocks, there is a hydraulic cylinder near the edge of the dock under each main girder, and horizontal hydraulic cylinders and rams with chains and multiplying sheaves to haul the bridge backwards and forwards. To guide the bridge to its exact position in closing, a projecting horn was fixed underneath the nose of the bridge, which entered a groove with a sloping bottom on the further coping, and a very curious phenomenon occurred in connection with this soon after the bridge was completed. Upon attempting to close the bridge one afternoon it was found that the horn was

too low to enter the groove, and a long time elapsed before the closing could be effected. The next time the bridge was used it entered all right, but again on one occasion it was too low. The engineer in charge considered the matter and came to the conclusion that the sun acting upon the dark painted bridge had caused a greater expansion in the top flanges of the girders than in the bottom flanges, and this had bowed the bridge downwards; he therefore had the bridge painted white, and the trouble immediately disappeared.

Lifting Bridges. Bascule bridges are sometimes called *lift bridges*, but the term properly belongs to those lifted bodily, of which, however, there are not many, and they are all of small span. There is one on the Grand Surrey Canal, in South London, which is lifted by hand-power gearing to allow barges to pass under.

Pontoon Bridges. Another form of bridge is the military pontoon system, and its allied type, the bridge of boats. These are only of a temporary nature, and hardly within the scope of this article, but they deserve to be mentioned as there is a large permanent bridge based upon the floating pontoon principle over the River Hooghly at Calcutta. Another form of pontoon is the caisson, either rectangular or boat-shape, used to close the mouth of a graving dock, or dry dock. It is floated into position, and then water is admitted to the interior to sink it; the pressure of the water in the outer dock when the graving dock is pumped dry keeps it in position. When it is desired to remove the caisson, water is admitted to the graving dock through the sluices; the water in the caisson is then pumped out, allowing it to float so that it can be removed.

Transporter Bridges. A new system of transit across rivers has recently been developed to which the name of *transporter bridges* has been given. The transporter bridge across the Mersey [38] forms a most useful connection between the towns of Widnes and Runcorn. It is in design precisely similar to an ordinary stiffened suspension bridge, with the exception that the approaches to the bridge are at a low level—thus dispensing with the very costly high level approaches—and the traffic, both foot and wheel, is carried over in a car suspended to the under side of the bridge, and is worked electrically. The transporter car consists of a platform 55 ft. long by 54 ft. wide, and is suspended from the trolley by steel wire ropes, hung so that they prevent both side and end oscillation of the car. It is capable of holding at one time four two-horse farmers' waggons loaded and 300 passengers, the latter being protected from the weather by a glazed shelter with folding doors at the end and side. On the top of the car is fixed the operator's cabin, in which is placed the switchboard, so that the operator has a full view of the course and has the car quite at his command. The time occupied by the car in crossing is about 2½ minutes; so, allowing the time for loading and unloading, it is capable of making about nine or ten trips per hour. The bottom of the car is about 12 ft. above high-water level, and clears the Ship Canal wall by about 4 ft. 6 in. The transporter is carried from the lower flanges of the stiffening girders, on which are fixed the rails upon which runs the trolley, from which is suspended the car. The trolley is about 77 ft. long, and is carried by 16 wheels on each rail. It is propelled by two electric motors of about 35 B.H.P. each, a large excess of propelling power being provided, partly for economy of working and principally to be ready for any emergency of strong head winds with heavy load. The motors are fixed to a kind of bogie arrangement in the trolley, so that in the case of large curvature of the bottom boom of the stiffening girders, due to either temperature or load, the driving wheels would be certain to bear hard on the rails.

38. WIDNES AND RUNCORN TRANSPORTER BRIDGE

The battery consists of 245 cells of "Chloride Accumulator," S. G. 3 type, arranged in glass boxes, and is capable of giving 90 amperes for one hour or 150 amperes momentarily. Between plates of opposite polarity is a thin sheet of wood held in position by wood dowels resting on the bottom of the box. This method of separation eliminates all possibility of short circuits between the plates and reduces to a minimum the amount of attention required by the cells.

Mr. J. J. Webster, of Westminster, and Mr. J. T. Wood, of Liverpool, were the consulting engineers for the whole work, the electrical equipment being carried out by Messrs. Mather and Platt, of Manchester.

Bridges concluded

continued from page 2751

THE REMAINDER THEOREM

Harder Examples in Factors. The Remainder Theorem used in Factorising Multinomials. Highest Common Factor and Lowest Common Multiple

By HERBERT J. ALLPORT, M.A.

FACTORS—continued

63. We shall now work a few miscellaneous examples in factors.

Example **1**. Find the factors of

$$(x^2+5x)^2-8(x^2+5x)-84.$$

This is equivalent to $y^2-8y-84$, if we suppose x^2+5x to equal y. The factors of the latter expression are $(y+6)(y-14)$.

Hence, we have

$$\begin{aligned}&(x^2+5x)^2-8(x^2+5x)-84\\&=(x^2+5x+6)(x^2+5x-14)\\&=(x+2)(x+3)(x+7)(x-2)\ \underline{\textit{Ans.}}\end{aligned}$$

Example **2**. Put into factors

$$(x+3)(x+4)(x+6)(x+7)-40.$$

This is easily reduced to the form of Ex. **1**. For we notice that $(x+3)(x+7)$ gives $x^2+10x+21$, and $(x+4)(x+6)$ gives $x^2+10x+24$, so that each product contains the terms x^2+10x. We therefore treat x^2+10x as if it were a single term, y. Thus

$$\begin{aligned}&(x+3)(x+4)(x+6)(x+7)-40\\&=(x^2+10x+21)(x^2+10x+24)-40\\&=(x^2+10x)^2+45(x^2+10x)+504-40\\&\quad[\text{since } (y+21)(y+24)=y^2+45y+504]\\&=(x^2+10x)^2+45(x^2+10x)+464\\&=(x^2+10x+16)(x^2+10x+29)\ [\text{See Ex. } \mathbf{1}]\\&=(x+2)(x+8)(x^2+10x+29)\ \underline{\textit{Ans.}}\end{aligned}$$

Example **3**. Find the factors of

$$(y+z)(z+x)(x+y)+xyz.$$

The product of $(x+y)$ and $(x+z)$ is

$$x^2+(y+z)x+yz.$$

Hence, the given expression

$$\begin{aligned}&=(y+z)\{x^2+(y+z)x+yz\}+xyz\\&=x^2(y+z)+x(y+z)^2+yz(y+z)+xyz.\end{aligned}$$

The first two of these expressions contain a common factor $x(y+z)$, and the last two contain a common factor yz, so that we proceed as in Art. **55** and obtain

$$\begin{aligned}&=x(y+z)(x+y+z)+yz(x+y+z)\\&=(x+y+z)\{x(y+z)+yz\}\\&=(x+y+z)(yz+zx+xy)\ \underline{\textit{Ans.}}\end{aligned}$$

Example **4**. Find the factors of

$$x^2(y-z)+y^2(z-x)+z^2(x-y).$$

Arrange the given expression in powers of x, and we get

$$x^2(y-z)-x(y^2-z^2)+y^2z-yz^2$$

or

It is now evident that $(y-z)$ is a factor of the expression. Thus, we have

$$\begin{aligned}&(y-z)\{x^2-x(y+z)+yz\}\\&=(y-z)(x-y)(x-z)\ \underline{\textit{Ans.}}\end{aligned}$$

64. **Rational Integral Expression.** A result which is of great use in finding factors is that known as the Remainder Theorem.

Before enunciating the theorem we must define "a rational integral expression."

An expression is said to be integral when it does not contain a *letter* in the denominator of any term. It is said to be *integral with respect to any particular letter* when it does not contain that letter in the denominator of any term. Thus, $\frac{x^2}{3a}-\frac{2xy}{4b}$ is integral with respect to x.

An expression is *rational* when none of its terms contain square or other roots.

The Remainder Theorem. If an expression which is integral with respect to x, and rational, be divided by $x-a$, the remainder is equal to the result obtained by substituting a for x in the expression.

For the sake of shortness we shall use the symbol S_x to denote the expression which is rational and integral with respect to x. Thus, S_x may stand for some such expression as x^4-7x^2+9. Then the symbol S_a will stand for the result obtained by substituting a for x in this expression—*i.e.*, for a^4-7a^2+9.

Next, suppose we divide the expression S_x by $x-a$. The remainder, if there be one, will be of a lower degree than the divisor—*i.e.*, *the remainder will not contain x*. Suppose we denote the quotient by Q, and the remainder by R. Then, since

Dividend = Quotient × Divisor + Remainder,

we have

$$S_x = Q(x-a)+R \quad . \quad . \quad . \quad \text{(i.)}.$$

This result is true whatever be the value of x. It will therefore be true when x equals a. But, when $x=a$, the factor $x-a$ equals 0, and therefore the product $Q(x-a)$ equals 0. Also, since R *does not contain x*, it is unaltered by substituting a for x. Thus, the result (i.) becomes

that is, the remainder is equal to the result obtained by substituting a for x in the given expression.

65. Again, if $x-a$ is a factor of the expression S_x, there will be no remainder when we divide S_x by $x-a$, *i.e.*, $R=0$, and, therefore, $S_a=0$.

Hence, *if, when a is substituted for x in an expression which is rational and integral with respect to x, the result is zero, then $x-a$ is a factor of the expression.*

factors.

If we substitute 1 for x in this expression, we obtain $1-3-13+15$, which equals 0. Hence it follows that $x-1$ is a factor of the expression. By actual division we can find the other factor,

but a better method is as follows. Remember that our object is to find by what $x-1$ must be multiplied in order to obtain $x^3-3x^2-13x+15$. Clearly, if we multiply $x-1$ by x^2 we obtain the term x^3, but we also obtain $-x^2$. We, therefore, still require $-2x^2-13x+15$. In a similar way, if we multiply $x-1$ by $-2x$ we obtain the necessary $-2x^2$, but we also get $2x$. To make this agree with the given expression requires $-15x+15$, *i.e.*, $-15(x-1)$. Thus, we see that

$$x^3-3x^2-13x+15$$
$$=x^2(x-1)-2x(x-1)-15(x-1),$$

and that $x-1$ is a factor is now evident, the expression being

$$=(x-1)(x^2-2x-15), \text{ which, by Art. 57,}$$
$$=(x-1)(x+3)(x-5).$$

Example 2. Resolve $x^3-2x^2-14x-12$ into factors.

In this case the result is not zero when we put $x=1$, or when we put $x=2$, or when $x=-1$. But, if we try $x=-2$, we obtain $-8-8+28-12$, which is equal to 0. Hence $x-(-2)$, *i.e.*, $x+2$ is a factor. The rest of the process is the same as in Example 1. Thus

$$x^3-2x^2-14x-12$$
$$=x^2(x+2)-4x(x+2)-6(x+2)$$
$$=(x+2)(x^2-4x-6) \ \underline{Ans.}$$

Note that it is useless to substitute values of x which are not factors of 12. For, if $x-a$ divides $x^3-2x^2-14x-12$, it is clear that a must divide the term 12.

Similarly, in Example 1, we only need try factors of 15, *i.e.*, 1, 3, 5, 15, or the same values with negative signs.

EXAMPLES 18

Resolve into factors

1. $(x^2+2x)^2-11(x^2+2x)+24$.
2. $(x+1)(x+2)(x+3)(x+4)-48$.
3. $(x+2)(x+4)(x+5)(x+7)+8$.
4. $x^3(y-z)+y^3(z-x)+z^3(x-y)$.
5. $(b-c)^3+(c-a)^3+(a-b)^3$.
6. x^3+3x^2-6x-8.
7. x^4+4x+3.
8. $yz(y-z)+zx(z-x)+xy(x-y)$.

HIGHEST COMMON FACTOR

66. The Highest Common Factor, or H.C.F., of two or more algebraical expressions is the expression of highest dimensions [Art. **29**] which will divide each of them without a remainder.

67. The H.C.F. of simple expressions can be written down by inspection.

Example 1. Find the H.C.F. of x^2yz and x^3yz^2.

The first expression is divisible by x and by x^2. The second is divisible by x, by x^2, and by x^3. Thus x^2 is the highest power of x which will divide both. Similarly, y is the highest power of y which will divide both, and z is the highest power of z. Thus the H.C.F. of x^2yz and x^3yz^2 is x^2yz.

Example 2. Find the H.C.F. of $36a^2b^3c$, $24a^4b^4c^2$, and $27a^3b^2c$.

By arithmetic we find that 3 is the H.C.F. of the coefficients 36, 24, 27. As in Example 1, the highest power of a which divides all three expressions is a^2, the highest power of b is b^2, and the highest power of c is c.

Hence, the required H.C.F. is $3a^2b^2c$.

Thus, to write down the H.C.F. of two or more simple expressions, we

(i.) Write down the H.C.F. of the numerical coefficients.

(ii.) Write down each letter which is common to all the expressions, and raise it to the lowest power in which it occurs.

68. The H.C.F. of multinomial expressions can be seen by inspection if we know the factors of the multinomials. We have only to write down each *factor* which is common to the expressions, and raise it to the lowest power in which it occurs.

Example 1. Find the H.C.F. of x^2-x-6 and $2x^2-7x+3$.

We have

$$x^2-x-6=(x-3)(x+2)$$

and

$$2x^2-7x+3=(x-3)(2x-1)$$

Hence, the H.C.F. is $x-3$.

Example 2. Find the H.C.F. of $8a^4+4a^3b-4a^2b^2$, $6a^3+18a^2b+12ab^2$, and $2ab(a^2-b^2)$.

Resolving each expression into factors, we get

$$8a^4+4a^3b-4a^2b^2=4a^2(2a^2+ab-b^2)$$
$$=4a^2(a+b)(2a-b)$$
$$6a^3+18a^2b+12ab^2=6a(a^2+3ab+2b^2)$$
$$=6a(a+b)(a+2b)$$
$$2ab(a^2-b^2)=2ab(a+b)(a-b).$$

The H.C.F. of the numerical coefficients 4, 6, 2 is 2; of the monomial factors a^2, a, ab is a; and of the remaining factors is $(a+b)$.

Thus the H.C.F. of the given expressions is $2a(a+b)$.

EXAMPLES 19

Find the H.C.F. of

1. $3abc^2$, $2a^2bc^3$, $5a^2b^2c^2$.
2. $4x^3y^2z$, $16x^2yz^3$, $10x^4yz^2$.
3. $21x^7y^3z^3$, $35x^3y^4$, $28x^5y^3z^3$.
4. $x^2-4x-12$, $x^2-3x-18$.
5. $x^2+3xy-4y^2$, $x^2+5xy+4y^2$.
6. $2a^2+5a-3$, $4a^2+4a-3$, $2a^2-5a+2$.
7. $6a^2+7ab-3b^2$, $4a^2+12ab+9b^2$, $10a^2+11ab-6b^2$.
8. $2x^2(x-2y)^3(3x+y)$, $4x^3(x-2y)(3x+y)^2$.
9. $12x^5+6x^4y-6x^3y^2$, $30x^3-105x^2y+45xy^2$.

69. H.C.F. of any Two Multinomials. By a method analogous to that used in Arithmetic [Art. **60** Arith., page 339] we can find the H.C.F. of *any* two multinomial expressions.

We can prove the same proposition for algebraical expressions as was proved for the two numbers in Article **59** of Arithmetic—*viz.*, *the common factors of a divisor and a dividend are the same as the common factors of the divisor and the remainder.*

Suppose A and B stand for two multinomials, having some common letter, x. Arrange A and B in descending powers of x, and suppose A is not of higher dimensions than B. Divide B by A; let Q be the quotient and R the remainder.

Then

$$B = AQ + R \quad . \quad . \quad . \quad . \quad (i.)$$

and, by transposing the term AQ we have

$$R = B - AQ \quad . \quad . \quad . \quad . \quad (ii.).$$

Now, a factor which divides both A and R must evidently be a factor of AQ + R also; so that from (i.) we see that it divides B. Thus, any common factor of A and R must also be a common factor of A and B.

In the same way, from (ii.) we see that any common factor of A and B must also be a common factor of A and R.

Clearly, then, the common factors of A and B are the same as the common factors of A and R.

If we now divide A by R, the H.C.F. of the new remainder and R will, exactly as before, be the same as the H.C.F. of A and R, *i.e.*, of A and B.

We have, therefore, only to continue the process of dividing the remainder into the previous divisor until we reach the stage where there is no remainder. The last divisor is the required H.C.F.

70. The above is only used to find the *compound* factor of the H.C.F. If the given expressions contain *simple* factors, these must be removed first [Art. **54**]. If these simple factors have any H.C.F., it is found by inspection, and multiplied into the compound factor found by the process of Art. **69**.

71. Remembering that the process is only used for finding the *multinomial* factor of H.C.F., and that each remainder contains the H.C.F. we are seeking, it is clear that we may multiply or divide any of the divisors or dividends by any *monomial* expression whenever the process of division renders this necessary. Instances of this occur in the second of the following examples.

Example **1**. Find the H.C.F. of $x^2 - 2x - 35$ and $x^3 - 3x^2 - 32x + 28$.

It is generally best to arrange the work in the manner explained in Ex. **2**, Art. 76, page 547, of Arithmetic.

$x + 5$	$x^2 - 2x - 35$	$x^3 - 3x^2 - 32x + 28$	$x - 1$
	$x^2 - 7x$	$x^3 - 2x^2 - 35x$	
	$5x - 35$	$-x^2 + 3x + 28$	
	$5x - 35$	$-x^2 + 2x + 35$	
		$x - 7$	

Thus, the H.C.F. is $x - 7$.

Explanation. We divide $x^2 - 2x - 35$ into $x^3 - 3x^2 - 32x + 28$, the quotient being $x - 1$, and the remainder $x - 7$. This remainder is then divided into $x^2 - 2x - 35$, giving a quotient $x + 5$, and *no remainder*. Hence $x - 7$, the last divisor used, is the required H.C.F.

Example **2**. Find the H.C.F. of

$$16a^4 + 4a^2 + 1 \text{ and } 8a^4 - 16a^3 + a - 2.$$

	$8a^4 - 16a^3 + a - 2$	$16a^4 + 4a^2 + 1$	2
	4	$16a^4 - 32a^3 + 2a - 4$	
a	$32a^4 - 64a^3 + 4a - 8$	$32a^3 + 4a^2 - 2a + 5$	
	$32a^4 + 4a^3 - 2a^2 + 5a$	17	
$-17a - 8$	$-68a^3 + 2a^2 - a - 8$	$544a^3 + 68a^2 - 34a + 85$	-8
	$-68a^3 + 34a^2 - 17a$	$544a^3 - 16a^2 + 8a + 64$	
	$-32a^2 + 16a - 8$	$21)84a^2 - 42a + 21$	
	$-32a^2 + 16a - 8$	$4a^2 - 2a + 1$	

The H.C.F. is $4a^2 - 2a + 1$.

Explanation. Divide $8a^4 - 16a^3 + a - 2$ into the other expression. The remainder is $32a^3 + 4a^2 - 2a + 5$. This has now to be divided into $8a^4 - 16a^3 + a - 2$; so, in order to avoid fractions, we multiply the dividend by 4, obtaining $32a^4 - 64a^3 + 4a - 8$. Proceeding with the division we obtain quotient a, and remainder $-68a^3 + 2a^2 - a - 8$. Now divide this remainder into the divisor we have just been using—*viz.*, $32a^3 + 4a^2 - 2a + 5$. In order to do this, the latter expression must be multiplied by 17. [To obtain the 17, take the L.C.M. of the coefficients of a^3, 68, and 32. This is $4 \times 17 \times 8$; hence 17 times 32 will be divisible by 68.] The remainder is $84a^2 - 42a + 21$. This contains a factor 21, and since 21 is not a factor of the given expressions, we reject the 21, and proceed with $4a^2 - 2a + 1$ for our divisor. This last expression divides $-68a^3 + 2a^2 - a - 8$ without a remainder, and is therefore the H.C.F.

72. To find the H.C.F. of three expressions A, B, C, we first find the H.C.F. of A and B, and then the H.C.F. of this result and C. Clearly, we shall then have found all the factors which are common to A, B, and C.

EXAMPLES 20

Find the H.C.F. of

1. $2x^3 - 5x^2 + 7x + 5$, $4x^3 - 11x^2 + 17x + 5$.
2. $6x^3 - 7x^2 + 10x - 4$, $4x^3 - 4x^2 + 15x - 7$.
3. $a^3 + 2a^2b - b^3$, $a^4 + a^3b - 2ab^3 - 2b^4$.
4. $2a^3 - 4a^2 + 9a - 8$, $2a^3 + 5a^2 + a - 8$.
5. $8x^3 - 8x^2 - 4x - 3$, $2x^4 + 3x^3 - 3x^2 - 7x - 3$.
6. $4x^4 - 4x^3 + x^2 - 1$, $2x^3 + 5x^2 - 2x + 3$.
7. $8x^3 - 10x^2 - 16x - 3$, $6x^4 - 22x^3 + 31x^2 - 23x - 7$.
8. $2x^3 - 23x^2 + 43x - 8$, $x^4 - 5x^3 - 6x^2 + 35x - 7$.

LEAST COMMON MULTIPLE

73. The Lowest Common Multiple, or L.C.M., of two or more algebraical expressions is the expression of lowest dimensions which is exactly divisible by each of them.

74. L.C.M. of Simple Expressions. The L.C.M. of simple expressions can be written down by inspection.

Example **1**. Find the L.C.M. of x^3yz, xy^4z^2, and y^2z^3.

Here, the highest power of x which occurs in any of the expressions is x^3. Any common multiple of the expressions must, therefore, contain the factor x^3. Similarly, since y^4 is the highest power of y which occurs, any common multiple must contain the factor y^4; and since z^3 is the highest power of z which occurs, any common multiple must contain the factor z^3. Evidently, then, the common multiple of lowest

dimensions is $x^3y^4z^3$. That is, the L.C.M. is

Example 2. Find the L.C.M. of $3x^2y$, $2xz^2$, $8xyz$, and $6y^2z$.

The required L.C.M. must contain each of the numerical factors 3, 2, 8, 6. The L.C.M. of these numbers is 24. Thus 24 is the coefficient of the L.C.M. required.

Again, as in Example 1, since the highest powers of x, y, and z which occur are x^2, y^2, and z^2 respectively, their L.C.M. is $x^2y^2z^2$.

Hence the L.C.M. of the given expressions is $24x^2y^2z^2$.

Thus, to find the L.C.M. of simple expressions, we

(i.) Find the L.C.M. of the numerical coefficients. This will form the coefficient of the required L.C.M.

(ii.) Write down each letter contained in the expressions, and raise it to the highest power which occurs among the expressions.

75. L.C.M. of Multinomials whose Factors are Known. The principle is the same as for monomial expressions. Write down each *factor* that occurs, raised to the highest power which it has in any expression.

Example 1. Find the L.C.M. of

$x^2 + 2ax + a^2$, $x^2 - a^2$, and $x^2 + ax - 2a^2$.

We have

$$x^2 + 2ax + a^2 = (x + a)^2$$
$$x^2 - a^2 = (x + a)(x - a)$$
$$x^2 + ax - 2a^2 = (x - a)(x + 2a).$$

The factor $(x + a)$ occurs, raised to the *second* power; $(x - a)$ and $(x + 2a)$ each occur as the first power. Hence the L.C.M. is

$$(x + a)^2 (x - a)(x + 2a).$$

Example 2. Find the L.C.M. of

$2a^4 - 2a^3b - 4a^2b^2$, $9a^3b + 12a^2b^2 + 3ab^3$, and $12a^2b^2 - 20ab^3 - 8b^4$.

Here

$$2a^4 - 2a^3b - 4a^2b^2 = 2a^2(a^2 - ab - 2b^2)$$
$$= 2a^2(a - 2b)(a + b)$$
$$9a^3b + 12a^2b^2 + 3ab^3 = 3ab(3a^2 + 4ab + b^2)$$
$$= 3ab(3a + b)(a + b)$$
$$12a^2b^2 - 20ab^3 - 8b^4 = 4b^2(3a^2 - 5ab - 2b^2)$$
$$= 4b^2(3a + b)(a - 2b).$$

As in Article **74**, the L.C.M. of the monomial factors $2a^2$, $3ab$, and $4b^2$ is $12a^2b^2$. The L.C.M. of the given expressions is therefore

$$12a^2b^2(a - 2b)(a + b)(3a + b).$$

EXAMPLES 21

Find the L.C.M. of

1. $9abc$, $15a^2b$, $2b^2c^3$.
2. $a^2 - b^2$, $(a + b)^2$, $(a - b)^2$.
3. $x^3 + y^3$, $x^3 - y^3$, $x^4 + y^4 + x^2y^2$.
4. $4x^2 + 8x - 12$, $9x^2 - 9x - 54$, $6x^4 - 30x^2 + 24$.
5. $6x^2 + 17x + 12$, $4x^2 - 4x - 15$, $6x^2 - 7x - 20$.
6. $4x^2 - 9$, $4x^2 - 12x + 9$, $6x^2 - 13x + 6$, $6x^2 + 5x - 6$.
7. $x^2 - 5xy + 6y^2$, $x^2 - 4xy + 3y^2$, $x^2 - 3xy + 2y^2$.
8. $x^2 - 4y^2$, $2xy - 6y^2$, $4xy^3 - 2x^2y^2$.
9. $a^3 + a^2b$, $2a^2 - 2b^2$, $a^2b^2 - ab^3$, $4a^3b$.
10. $2x^2 + 3x - 2$, $(5x - 7)^2 - (x - 5)^2$, $2x^3 - x^2 - 8x + 4$.

76. When the factors of the expressions whose L.C.M. is required cannot be seen by inspection, we use the H.C.F. rule.

Let A and B stand for two algebraical expressions whose highest common factor is H, and whose lowest common multiple is L.

Divide A and B by H, and let the quotients be a and b respectively. Then

$$A = a \times H,$$

and

$$B = b \times H.$$

Now, since H is the highest common factor of A and B, it follows that a and b can have no common factors. Therefore the L.C.M. of A and B is $H \times a \times b$; that is

$$L = H \times a \times b.$$

But $H \times a = A$, therefore

$$L = A \times b.$$

Hence, *the L.C.M. of two algebraical expressions is obtained by dividing one of the expressions by their H.C.F., and multiplying the quotient by the other expression.*

77. Another important result is obtained from the relation

$$L = H \times a \times b.$$

Multiplying both sides by H, we have

$$L \times H = H \times a \times H \times b.$$

But $H \times a = A$, and $H \times b = B$. Hence

$$L \times H = A \times B;$$

or, *the product of any two expressions is equal to the product of their H.C.F. and their L.C.M.*

78. To find the L.C.M. of more than two expressions, whose factors cannot be readily seen, we find the L.C.M. of any two of the expressions, then the L.C.M. of this result and a third expression, and so on until we have used every expression.

EXAMPLES 22

Find the L.C.M of

1. $2x^3 - 11x^2 + 20x - 21$ and $4x^3 - 4x^2 - 41x + 21$.
2. $a^3 - 6a^2 + 11a - 6$ and $a^3 - 10a^2 + 29a - 20$.
3. $8x^3 - 18x^2 + 13x - 3$ and $6x^3 - 13x^2 + 9x - 2$.
4. $2x^3 - 5x^2y + 4xy^2 - y^3$, $2xy^2 + x^2y - y^3 - 2x^3$, and $2x^3 + 3x^2y - y^3$.

Answers to Algebra

Examples 11

1. $x(x^2 + 6)$.
2. $a(a + b + c)$.
3. $11abc(ab - 3c^2)$.
4. $x(3x^3 - 2xy^2 + y^3)$.
5. $5y^3(y - 4x)$.
6. $3yz(13xy + 15z)$.
7. $2a(3x^3 + 2ax - 4a^2)$.
8. $17(4 - 3x^2)$.
9. $19abc^2(6a^3 + 5b)$.

Examples 12

1. $(x + a)(x + b)$.
2. $(a + 1)(b^2 + 1)$.
3. $(x - y)(ax - by)$.
4. $(a + b)(c - d)$.
5. $(x^2 + 2)(y^2 - 2)$.
6. $(x + 2y)(a - b)$.
7. $(x^2 + 1)(x - a)$.
8. $(a + bc)(x - yz)$.
9. $(x^2 + 2y^2)(x^2 + 2z^2)$.
10. $(x^3 + 2a)(y^3 - 3a)$.

Examples 13

1. $(x+2)^2$.
2. $(y-3)^2$.
3. $(5a-2b)^2$.
4. $-3\,(a^2+1)^2$.
5. $4\,(x^2+y)^2$.
6. $2a^2\,(x+b)^2$.
7. $(x+y+z)^2$.
8. $(a+b-\frac{1}{2}c)^2$.

Examples 14

1. $(x+1)\,(x+2)$.
2. $(y-3)\,(y-5)$.
3. $(x+4)\,(x-7)$.
4. $(a+17)\,(a-3)$.
5. $(y+15)\,(y-16)$.
6. $(x+5)\,(x-30)$.
7. $(y+1)\,(y+50)$.
8. $(a-3b)\,(a-14b)$.
9. $(x+13y)\,(x-14y)$.
10. $(x-11y)\,(x-16y)$.
11. $2\,(x+15y)\,(x-3y)$.
12. $3\,(a+12b)\,(a-14b)$.

Note. No. 12 should read $3a^2-6ab-504b^2$.

Examples 15

1. $(2x-1)\,(x-2)$.
2. $(2x+3)\,(3x+5)$.
3. $(3x+y)\,(7x-4y)$.
4. $(13x-2y)\,(2x+7y)$.
5. $(12x+1)\,(11x-2)$.
6. $(9x-2)\,(x+16)$.
7. $(17x-3y)\,(x-5y)$.

Note. The question should read $17x^2-88xy+15y^2$.

8. $4x\,(x-2)\,(3x-1)$.
9. $2xy\,(11x-3y)\,(5x+4y)$.
10. $2\,(4x-1)\,(x-4)$.

Examples 16

1. $(x+11)\,(x-11)$.
2. $(a+4b)\,(a-4b)$.
3. $(1+5y)\,(1-5y)$.
4. $(ab+7)\,(ab-7)$.
5. $(6+xy)\,(6-xy)$.
6. $2\,(4x+3y)\,(4x-3y)$.
7. $(2x+5y+x-3y)\,(2x+5y-x+3y)$
   $= (3x+2y)\,(x+8y)$.
8. $(a+2b+a-2b)\,(a+2b-a+2b)$
   $= 2a\,.\,4b = 8ab$.
9. $(3a+3b+a-b)\,(3a+3b-a+b)$
   $= (4a+2b)\,(2a+4b)$
   $= 4\,(2a+b)\,(a+2b)$.
10. $(a^2+5)^2-16a^2$
    $= (a^2+4a+5)\,(a^2-4a+5)$.
11. $(x^2-2y^2)^2-36x^2y^2$
    $= (x^2+6xy-2y^2)\,(x^2-6xy-2y^2)$.
12. $(y^2-1)^2-4y^2$
    $= (y^2+2y-1)\,(y^2-2y-1)$.

Examples 17

1. $(a+5b)\,(a^2-5ab+25b^2)$.
2. $(3a-4b)\,(9a^2+12ab+16b^2)$.
3. $(x^2-2y^2)\,(x^4+2x^2y^2+4y^4)$.
4. $2x^2\,(x+2y)\,(x^2-2xy+4y^2)$.
5. $(a+2b-a)\,(a^2+4ab+4b^2+a^2+2ab+a^2)$
   $= 2b\,(3a^2+6ab+4b^2)$.
6. $\left(2a-\frac{4}{b}\right)\left(4a^2+\frac{8a}{b}+\frac{16}{b^2}\right)$.
7. $(a-2b-b+2a)\;(a^2-4ab+4b^2+5ab-2a^2$
   $-2b^2+b^2-4ab+4a^2)$
   $= (3a-3b)\,(3a^2-3ab+3b^2)$
   $= 9\,(a-b)\,(a^2-ab+b^2)$.
8. $\left(\frac{x}{7}-\frac{3}{x}\right)\left(\frac{x^2}{49}+\frac{3}{7}+\frac{9}{x^2}\right)$.
9. $\left(\frac{ab}{10}+5\right)\left(\frac{a^2b^2}{100}-\frac{ab}{2}+25\right)$.

Continued

COUNTS OF YARNS

Hank Weights and Lengths of the Various Textile Fibres. Methods of Measurement Adopted in Different Branches of the Industry

Continued from page 2709

By W. S. MURPHY

BEFORE quitting this section of our course, we must endeavour to understand what meaning should be attached to the various terms used in defining the qualities and lengths of yarns. On the very threshold of the subject we are confronted by what seems an inexplicable tangle. Different fibres are counted on units widely different. Not only is this so, but we find that some systems count up where others count down. In addition, we have local methods of calculating, which, though seemingly unimportant from a general standpoint, derive practical importance from the fact that the localities in which the terms are used have a very large share of the trade. We may say that the Yorkshire skein is not a unit of great importance, because that county is only a small part of England; but when we remember that Yorkshire contains more woollen factories than all the rest of the United Kingdom, the unit of measurement used by Yorkshiremen becomes highly significant indeed. Were we at liberty to inquire, we would probably learn that every different method of counting textile yarns had a historical origin, and was quite rational and right when it was adopted. For example, the wool industries are deeply embedded in our national history, and the cotton industries are of comparatively recent origin. What do we find? The variations in the wool methods are perplexing, while the whole cotton industry has only one method of counting yarns.

Cotton. When cotton came to this country, the woollen workers had already invented a method of counting the hanks of yarn which was practical and convenient to the reelers. To reel a heavy hank of yarn in one place on the reel was not suitable. Therefore, the reelers put a spring on the reel which would give a snap, or rap, every 80 revolutions, and at the warning the reeler started in a new place on the reel. When seven of these raps had been wound, it was considered a hank. The reel being exactly 1 yd. in circumference, the hank became 560 yd. in length. The cotton reelers adopted the same plan. But, for reasons we do not know, the cotton reel was made 54 in. in circumference, or ½ yd. more than the woollen reel. Therefore, the cotton hank was made 840 yd. long. Though differing by this accident from the woollen measure, the cotton method of counting has remained consistent within itself. The counts were numbered according to the number of hanks which were required to equal 1 lb. weight avoirdupois. So we now have it. When we say that a count is number 40, we mean that 40 hanks of that yarn will weigh 1 lb. Knowing that 840 yd. are in a hank, we can calculate how many yards of yarn are in 1 lb. of any given count.

Wool Yarns. The standard hank of 560 yd. is very generally accepted all through the trade, and the counts are numbered according to the number of hanks in 1 lb. But there are yet other systems which we cannot altogether ignore. The Yorkshire skein contains 1,536 yd. This was termed a "whartorn," in the diction of weight, and the modern equivalent is 6 lb. As we find, however, that there are just so many drams in 6 lb., we come to the conclusion that the Yorkshire skein is not a very mysterious entity after all. In effect, the standard of that count is 1 yd. to 1 dram. If there are 10 yd. in 1 dram, the count is 10. West of England manufacturers base their system upon 20 yd. to 1 oz. as the unit. That is, 100 yd. to 1 oz. is count number 5, 600 yd. to 1 oz. is count 30, and so on.

The unit of the Dewsbury system is 1 yd. to 1 oz.; 24 yd. in 1 oz. is 24's yarns, 96 yd. to 1 oz. is 96's, and upwards in the same ratio.

Sowerby Bridge, Yorkshire, has a totally different system. 80 yd. is the unit, and the dram is the standard weight, the number of the count being determined by the number of drams a hank of 80 yd. weighs. If it weigh 12 drams, the count is 12's, and if it weigh 24 drams, the count is 24's. Obviously, the common method of counting is here reversed. The finest counts are the lowest numbers.

Scottish Counts. The methods of counting yarns in Scotland are varied. One feature of the Scottish methods is the exclusive resort to measures independent of weights. The count system, properly so called, is a recent introduction from England.

What has been called the Aberdeen system was really prevalent all over Scotland. But each locality had a unit of its own. We give the Aberdeen table as the most complete:

1 reel	=	1 thread	=	2½	Yd.
120 threads	=	1 cut	=	300	,,
2 cuts	=	1 heer	=	600	,,
3 heers	=	1 slip	=	1,800	,,
2 slips	=	1 hank	=	3,600	,,
2 hanks	=	1 hesp	=	7,200	,,
2 hesps	=	1 spyndle	=	14,400	,,

The spyndle was the unit of length and 1 lb. the unit in weight; 1 spyndle equal to 1 lb. is yarn number 1, and the ratio proceeds on that basis. If the spyndle weighs 3 lb., the number of the yarn is number 3 count. Here again, the coarser the yarn the higher the count.

In Stirling district the cut is 240 yd., and the spyndle is 48 cuts, or 11,520 yd. Stirling unit

of weight is 24 lb., and the number of spyndles in that weight gives the number of the count. To take it another and simpler way, we say that the standard unit is 480 yd. to 1 lb. If there are 960 yd. in 1 lb., the yarn number is 2's.

On the Scottish border, the cut is 300 yd.; but Galashiels and Hawick adopt different standards of weight. The Galashiels system is based on the number of cuts in 24 oz.; the Hawick system makes 26 oz. to the cut the unit.

In America we find many systems; but those most commonly used are what they call the *grain* and the *run* systems. In the grain system the unit of length is 20 yd., and the unit of weight is the grain. If 20 yd. equal 1 grain, the yarn is count number 1. The length unit of the run system is 100 yd., and the weight unit is 1 oz.; 400 yd. weighing 1 oz. would be counted 4 run. The Stirling system is also used to a considerable extent in the United States.

Silks. Spun silk is counted according to the cotton system in all but one small particular. When cotton or wool yarns are doubled, the count is measured according to the hanks of the doubled yarn in 1 lb. The yarn is treated as a unity. In spun silk, the yarns composing a doubled thread are not allowed to lose their identity, and the yarn number remains the same, with the addition of the word "doubled." This has given rise to some confusion.

Raw silk has been the yarn most difficult to count. Three systems have been used: the "denier" scale, the ounce, and the dram. Neither in respect of weight nor length have we ever been able to get a definite standard on the denier system. Omitting gross miscalculations, we find that authorities vary from 0·693 to 0·854 of a grain as the equivalent in English weight of the denier. It is generally accepted, however, that the approximate weight of a denier is 0·825 of a grain, or 20 deniers to 16½ grains. The unit of length is equally indeterminate and confused. It is vaguely said to be 400 revolutions of a special reel, the circumference of which is about a yard. In reality the reel is only the old French reel, the circumference of which is a French ell, giving in the 400 revolutions 520 yards. The method of calculating at which we arrive on this system figures out in a result something like this: If a hank of silk containing 520 yards weigh 1 denier, it is number one count; if 120 deniers, it is 120's. The heavier the yarn, the higher the count. There is some reason in the system, because, in many cases, the heavier the silk the higher the quality.

Working on a similar plan is the *dram* system. In this system the hank, 1,000 yards long, is the length unit, and the count depends on the number of drams the hank weighs. The thicker the thread, therefore, the higher the count. The *ounce* system is more in accord with our ordinary methods of counting. The unit of length is the 1,000 yards hank, and according to the number of hanks in the ounce, the yarn number is fixed. A silk giving twenty hanks to the ounce would be 20's, and one giving 40 hanks to the ounce would be 40's.

Linen. The linen industry uses a complete table of lengths. In addition there is the count system, the length unit of which is the lea, or cut (300 yd.), and the weight unit 1 lb. The method of counting is according to the number of leas in a pound. One lea is 300 yd. to the 1 lb.; 100 lea is 30,000 yd. to the 1 lb.

Linen Yarn Table.

1 rev. of reel	= 1 thread	=	2½	yards.
120 threads	= 1 lea or cut	=	300	,,
12 cuts	= 1 hank	=	3,600	,,
16⅔ hanks	= 1 bundle	=	60,000	,,
20 ,,	= 1 reel	=	72,000	,,

Jute. This fibre has also a table of proportions measuring by length alone. The number of the yarn is described in terms based on the weight of a unit named the spyndle. The yarn in an 8-lb., 6-lb., 4-lb., or otherwise, according to the number of pounds a spyndle weighs. Of course, the coarser the yarn the higher the count.

Jute Yarn Table.

90 in.	= 1 thread	=	2½	yards.
120 threads	= 1 cut	=	300	,,
2 cuts	= 1 heer	=	600	,,
6 heers	= 1 hesp	=	3,600	,,
4 hesps	= 1 spyndle	=	14,400	,,

In the midst of such diversity of standards, the textile worker may well be pardoned for feeling confused. Without a common measure for the various yarns, and even bereft of the uniformity of procedure which always gives a help, he must rely on the teaching of experience for the most part. It is possible, however, to arrive at definiteness by careful calculation. Take the 20's count, for example, and try to find out how many yards of each yarn of the count will be in the pound weight.

Yarn.			Yards per lb.
Worsted	20's	=	11,200
Cotton	,,	=	16,800
Spun silk	,,	=	16,800
Raw silk (1,000 yd. per oz.)	,,	=	320,000
,, (,, dram)	,,	=	12,800
,, (denier scale)	,,	=	133,866⅔
Linen	,,	=	6,000
Woollen (Yorkshire skein)	,,	=	5,120
,, (West of England)	,,	=	6,400
,, (Dewsbury)	,,	=	320
,, (Sowerby Bridge)	,,	=	1,024
Aberdeen	,,	=	720
Stirling	,,	=	9,600
Galashiels	,,	=	4,000
Hawick	,,	=	3,692$\frac{4}{13}$
American "run"	,,	=	32,000
,, "grain"	,,	=	7,000

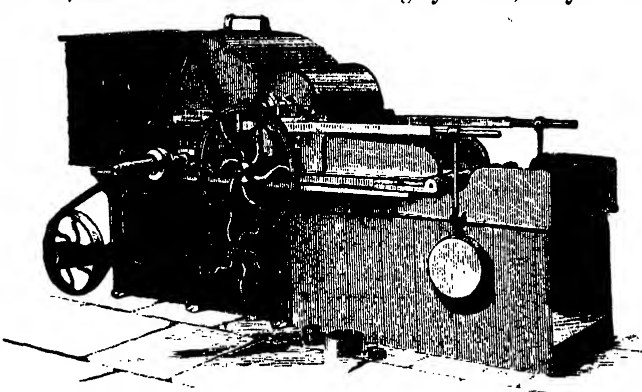
In four of these systems the counts are measured by the weight of the unit, the spyndles, or hanks; in all the others the counts are measured by the number of hanks in the pound weight. To show how this works, let us take count number one of the yarns, and see how

many yards we will find of each yarn in the pound.

Yarn		Yards per lb.
Worsted	=	560
Cotton	=	840
Spun silk	=	840
Raw silk (1,000-yd. per oz.)	=	16,000
„ („ dram)	=	256,000
„ (denier scale)	=	$4,437,333\frac{1}{3}$
Linen	=	300
Woollen (Yorkshire skein)	=	256
„ (West of England)	=	320
„ (Dewsbury)	=	16
„ (Sowerby Bridge)	=	20,480
Aberdeen	=	14,400
Stirling	=	480
Galashiels	=	200
Hawick	=	$184\frac{16}{28}$
American "run"	=	1,600
„ "grain"	=	350

UTILISING THE WASTE

Rags and Clippings. There are two kinds of waste—the waste which comes from the wear and tear of use, and the waste incurred in the processes of manufacture. In the woollen industry we utilise both kinds of waste. Clippings from the tailor and the dressmaker, worn out clothes, stockings and other kinds of hosiery, the gatherings of the ragman and the municipal cleansing department—all forms of wool, even down to loom dust and shearer's croppings, are accepted as raw material in the shoddy factory. Historically, this section of the textile industry has been divided into three divisions, or, strictly speaking, four; but at the present day the term *shoddy* is held to cover the whole. Four classes of material came successively into use. The order was as follows: (1) worsted rags, (2) woollen rags and scraps of milled cloths, (3) wool extracted by sulphuric treatment from cloths of mixed cotton and wool, destroying the cotton, (4) croppings of shearing in the finishing of cloths, and loom dust. Having glanced at these historically at the beginning of our course, we can now proceed to practical operations.



116. RAG TEARER, OR DEVIL (Sykes & Sons, Huddersfield)

Rugs from Clippings. Though not in the direct line of our study, one use to which the finest clippings of cloth are put is worth mentioning. New cloth clippings are used very largely in Huddersfield for cloth rug making. This is done by means of special machinery, in which the cloth is woven to form the "nap," or upper surface, of the rug.

Boiling. There are grades of rags, just as there are grades of poverty. Some rags sell as high as 1s. per lb., and the values run down to 1d. per lb., or even lower. Valuable rags are usually supplied to the manufacturer by merchants, who have already selected and roughly cleaned them, but the cheaper kinds come in bags, higgledy-piggledy, and these, before being touched, are thrown into huge boilers, and boiled with a strong disinfecting soap or liquid. The sorted, high-class rags are also boiled, but not so severely. These boilers are very ingeniously constructed. In the centre of the huge iron cylinder is a pipe with a spraying nozzle, and through this the boiling water keeps up a constant circulation, bringing up the detergent always to the top of the rags. The liquid sinks again through the boiling materials, carrying with it the dirt to the bottom, returning by the pipe again to perform another cleansing round.

Sorting. Cleansed rags of all grades are brought to the sorting department. The labour is not highly skilled, but you must have knowledge of textiles to do it efficiently, especially in these days when imitation has become an art. The classes are arranged according to the factory management; in some factories the classification is detailed and strict; in others, so long as the vegetable fibres are taken away, with the buttons and other hardware, nothing more is required. Generally, however, woollen and worsted rags are separated, and fine broadcloths, if by chance they should come in a mixed bundle, are set apart. With knife and scissors we cut away linings, threads, tags, buttons, and put the remnant into its appropriate basket.

Rag Tearing. The *devil* is the name given to the rag-tearing machine [116], and though it has a profane sound it has a purely technical meaning. On the head of the machine is a hopper, and into it the rags are fed. As the material comes down, it enters into contact with two spike cylinders, revolving at high speed in opposite directions, and closely set together. The spikes tear and grind at a great rate, churning the wool round and round. At the back of the machine a fan is constantly blowing, and as the wool becomes flocculent, the fan blows it out from the machine, while any heavier matters which may have escaped the sorters drop to the bottom of the machine. In this way the rags are kept within the grasp of the devil till they are light enough to be carried out by the wind of the fan. The severity of the devil

has been objected to, but the staple produced from it is about equal on the average to ordinary cotton.

Scouring. A short-stapled fibre like rag-wool does not require to be scoured with the same care as long wools. It is here that the raking, forking, and sousing washing machines, originally rejected by the wool scourers, have found their true use. Like the ordinary wool-scouring machines, these washers are divided into three compartments, the first containing strong scouring liquor, the second weaker liquor, and the third clean water. Laid in the first compartment, among the strong liquor, the rag-wool is soused and forked about till thoroughly cleansed; in the second division the material gets another bath, and in the third the water clears away all traces of the liquor.

There are various methods of drying. The simplest is the range of bars above the trough on which the wool is spread to drip and thence removed to more thorough drying. Squeezing tends to lump this soft material. For final drying, therefore, the centrifugal extractor is much preferred. As the rag-wool is nearly always dyed, the point to be aimed at is not so much perfect dryness as thorough cleanliness from the scouring liquor. When dried in this degree, the wool goes into the dyeing department, and is there prepared for the spinning process.

Extract. The rags which have been found to be mixed cotton and wool, and other "union" cloths, are subjected to a bath of dilute sulphuric acid. In lead-lined vats the rags are steeped among the acid till all the cotton has been destroyed. The fibres thus treated are then laid in the centrifugal extractor, which takes away the acid and preserves it for further use. Next, the wool is passed through the carboniser, or baking machine, which effectually converts into dust all the rotted vegetable fibre by means of dry heat. To take away the dust, the wool is passed through a simple blower, over the netted lattice of which it passes and drops out the dust, by the aid of a fan. Washed and dried in the usual way, the extracted wool is ready for use in the factory. The acid has made the wool harsh and brittle, but by careful treatment with oil we can obviate the defect somewhat. It is best to tease extract rags in the common wool opener, if a good use is to be made of it. Then in the oiling, a liberal dose applied with judgment helps to correct the harshness. Otherwise, extract is simply treated as an inferior shoddy.

Carbonising Wool. The extract process is also used for the purpose of freeing raw wool from burrs, though in a more elaborate way. Instead of being laid in the acid vat, the wool is caged in wire netting and let into the acid tank. After being completely saturated with acid, the wool is put through the centrifugal extractor, which draws out all the sulphuric acid, or as much of it as possible. Though killed by the acid, the vegetable matters yet remain, and these are reduced to powder in the baking machine, which is heated to a very high temperature. Next, the wool is passed through a burring machine, which grinds down whatever hard material has resisted treatment, and drives out all the pulverised matter with an exhaust fan. Washed in clear water to remove all traces of acid and clear away other impurities, the wool is dried.

Croppers' Dust. Croppings, loom dust, waste, and other such materials, are not much used in this country at the present day. When wool sells at 4d. per lb., and rags of fair quality can be bought at 1d., there is very little reason for using materials so low in textile quality. However, we admit that one use to which it is put is worth noting. The stuff is cleaned and reduced to uniform dust; then, with a mixture of soap and size, it is compacted into a thin sheet. The thin layer is laid upon a widely woven, strong gauze, and battered into it by a species of felting. The resultant cloth is heavy and almost impervious to water. Some demand for this cloth exists in Canada, North America, and Northern Europe.

Noils. The refuse of the combing machines, this material possesses all the highest qualities of wool. Having been already sorted, scoured, and oiled, it is equal to the best short wool, and is therefore passed on to the woollen factory, there to be mixed with the ordinary raw wools, or it may be reserved for the finest of the cloths of the factory. Noils are much in demand for the best qualities of felts, for which they make an ideal and comparatively cheap raw material. We say comparatively cheap because, as there is always a good market for noils, the values never sink below a very fair level. The manufacturing process of noils differs in no way from that of the ordinary carding or felting wool.

Mill Waste. Of a kind similar to noils, though on a lower plane, is the waste from the processes of manufacture. From the blowing-rooms and the carders a large quantity of wool is daily gathered. Mixed with dust, and generally inferior in length of staple, this waste is hardly fit for the highest purposes; but it is good and serviceable stuff for all that. Collected in bins, the waste is emptied into the waste shaker. Sometimes the common willow is used; but we think the sieve-like cylinder known as "Isett's Patent" is gentler and not less effective. When the waste has been freed from dust it is ready for being utilised in the way best suited to the factory.

It is a curious fact, and an illustration of the economic trend of the nineteenth century, that we can find little scope for improvement in the utilisation of waste materials, though there are yet many opportunities for young genius in the uses which are made of the staple materials of the textile industry.

Continued

RAINBOWS AND LENSES

Results of the Refraction of Light. The Rainbow of Sunlight. Primary and Secondary Rainbows. Lenses and Mirrors. The Microscope and Telescope

By Dr. C. W. SALEEBY

Refraction at Spherical Surfaces The application of the laws of refraction already stated to the case of spherical surfaces is not difficult. It will depend, of course, upon the refractive index of the media in question, and again we must employ the idea of a tangent plane, thus reducing the case to the simplicity of refraction at a plane surface. The special interest of refraction at a spherical surface is found in the case of the raindrop, and we may now proceed to a discussion of the rainbow, which depends for its formation and colour, and also for the presence of the secondary rainbow, upon the application of the laws of refraction and reflection to spherical surfaces, such as those exhibited by raindrops. The rainbow has long excited the interest of physicists and is now perfectly understood. Afterwards we must pass to more practical matters, and especially to the application of the laws of refraction in the various kinds of lenses.

The reader will not labour under the delusion that when we have stated the laws of reflection and refraction we have in any sense whatever explained them. What in fact is the relation of the ethereal disturbance to the matter through which it passes or from which it is turned back we can by no means say. The discovery of unbroken laws, regulating all these phenomena, may, however, be expected to lead us some day to an explanation of them. It is evident that wherever there are laws of phenomena there must ultimately be explanations of them, could these be discovered.

Refraction and the Rainbow. The wonderful phenomena of the rainbow have long excited the interests of physicists. It was early recognised that it is due to the manner in which the solar light is affected by drops of water. In order to see a rainbow, one must turn one's back upon the sun, and the bow which one sees is part of a circle, the centre of which lies in a straight line drawn from the sun to the observer's eyes. Given the necessary conditions, a rainbow may be seen even when there is no rain—as, for instance, in the spray of a waterfall.

The familiar phenomena depend upon the refraction of light at a spherical surface, such surfaces being provided by the individual drops of water. But, in order to explain the facts, it is desirable, according to Professor Tait, to begin, not with refraction at spherical surfaces, but with refraction as it occurs when light falls upon cylindrical surfaces. (It is hardly necessary to explain the meaning of the word "cylinder.") He says: " A far more interesting case [than that of the apparent magnification of the bulb of a thermometer when one looks at it from a little distance] is that of parallel rays falling on a solid cylinder of glass or water. Its interest consists in the fact that by its aid we can explain the phenomena of the rainbow. . . . The problem, without losing any of its applicability to the rainbow, is much simplified by supposing the rays to be incident in a direction perpendicular to the axis of the cylinder ; for in this case the whole course of each ray is in a plane perpendicular to the axis . . . what we are mainly concerned with is the behaviour of the rays which escape into the air after *one* or *two* reflections at the inner surface of the cylinder."

"Little Drops of Water" Make the Rainbow. The sun is so remote that the rays of light from it may be regarded as parallel, so that what is true of parallel rays will be practically true of the actual case we are considering. Tait goes on to show that the spherical drops of water that cause the rainbow are equivalent to the cylinders which he has been discussing. " For each spherical drop is effective only in virtue of a section through its centre, containing the incident ray and the eye ; and such sections are the same as those of the cylinders." He then shows that if we " suppose cylinders to be placed in great numbers, in all directions, perpendicular to the incident rays," the eye will perceive a bright circle of light, or rather the bright circumference of a circle of light, inside which there will be feeble illumination, while outside it there will be darkness. " This is obviously the case of the rainbow, where we have spherical drops of water instead of the cylinders above spoken of."

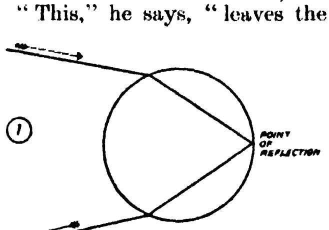
The truth of these assertions cannot here be demonstrated because such demonstration is highly complicated, and would require a good deal of acquaintance with terms which are not familiar. The essential fact, which we can only ask the reader to take on trust, is that the necessity of the phenomena of the rainbow can be mathematically deduced from the known laws of refraction and reflection.

The Rainbow of Sunlight. But so far we have discussed merely what will happen in the case of parallel rays of homogeneous light—that is to say, light all of one colour or all of one wave length. The result in such a case is " a bright circle whose centre is diametrically opposite to the source of light . . . and whose area is slightly illuminated." In order to discuss the actual case, however, two further complexities have to be considered, and this we shall do in Professor Tait's own words :

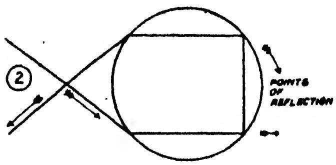
"Introduce the idea of the different kinds of homogeneous light which make up sunlight, and we find a circular (almost pure) spectrum, the less refrangible rays being on the outside. Next we introduce the consideration of the finite disc of the sun, and we have an infinite series of such arrangements superposed on one another, the centre of each individual of the series being at the point diametrically opposite to the point of the sun's disc which produced it."

The Primary Rainbow. This circular spectrum described by Tait, having the less refrangible rays on the outside, is, of course, the rainbow. There are a great number of further complexities which we need not consider here, but let us draw for ourselves the course of a ray of light entering a spherical raindrop, and let us see what happens to it. We shall find that there are two possibilities, according as the reflections at the inner surface of the drop are one or two. Compare the words italicised in the quotation from Professor Tait above. The case we have been considering is that of only one internal reflection, and it produces a rainbow which more properly should be called the *primary rainbow.* This, however, is not the only rainbow, as we shall see.

When a ray of light strikes a raindrop, it is refracted just as when it strikes a surface of water. Thus, it strikes the internal surface of the raindrop, from which it is reflected, so as to emerge from the raindrop ; but at the point of emergence a second refraction must occur. At both its refractions the composite light follows in all its parts the laws of refraction, and hence we see in the rainbow a series of concentric circles containing the colours of the spectrum, red being outermost, and succeeded by orange, yellow, green, blue, indigo, and violet. This, of course, is in agreement with what we have quoted from Professor Tait, "the less refrangible rays being on the outside." In the actual phenomenon, as Tait points out, the spectrum is not pure, because, as we have seen, of the superposition of the concentric arrangements, due to the fact that the sun has a disc, and is not a point. "This," he says, "leaves the general aspect of the phenomenon unchanged, but altogether destroys the purity of the spectrum." The accompanying diagram shows the course of a ray of light undergoing one internal reflection in a raindrop, and leading to the formation of the primary rainbow.



The Secondary Rainbow. It may be, however, that some of the light strikes the drop in such a fashion that it undergoes two internal reflections instead of one. The comparison between a cylinder and a raindrop holds in this case also. The result is a second rainbow, concentric with the first, but having a somewhat greater radius—that is to say, lying somewhat outside the primary rainbow. Professor Tait says of it: "All the above remarks about the impurity of the spectrum, etc., apply to this bow also. In this bow the less refrangible rays are on the *inner* side, and the straggling rays illuminate feebly the space *outside* it. Hence, the space between the red boundaries of the two bows has no illumination from rays reflected either once or twice within the water drops." The second diagram shows the course of the light which undergoes double internal reflection within a cylinder or raindrop.



Secondary Rainbow Explained. The fundamental parts of this explanation—"namely, (1) that the primary bow is due to rays falling on the outer portions of the drops, which suffer two refractions and one reflection before reaching the eye ; and (2) that the secondary bow is due to rays falling on the inner side, and suffering two refractions and two reflections"—are now nearly 600 years old. Newton made the great addition to the theory of applying to it his discovery that the different components of white light, which he proved to be compound, are differently refrangible. Since Newton's time the theory of the rainbow has been advanced still further, as might be expected, if we remember that Newton did not accept the undulatory theory of light. It is not the case that in each bow there is one place of maximum brightness for each particular colour. On the contrary, we find what are called "spurious bows," which often appear like ripples inside the primary and outside the secondary bow, and which depend upon the fact that in each bow there is more than one maximum of brightness.

White Rainbows. It is its colour which we always consider as characteristic of a rainbow, but we have already seen that this is not the essential fact. Rainbows would occur if the sun's light were homogeneous, or all of one colour. As it is, the complexity introduced by the disc of the sun may sometimes cause the colours to overlap one another so much that they neutralise one another and scarcely appear at all. "This may happen, for instance, when the sun shines on raindrops in the lower strata of the atmosphere, through clouds of ice crystals in the higher strata. By reflection from the faces of these crystals, the source of light is spread over a much larger spherical angle, and there is no sharp edge to it, as in the case of the unclouded disc. The rainbow is then much broader and fainter than usual, and nearly white."

Under favourable conditions one may obtain rainbows, colours and all, by means of the light of a full moon—"lunar rainbows."

Halos and Coronæ. We may follow Professor Tait in concluding this subject by a brief allusion to the appearances which are often

seen and which go by these names. Coloured halos are due to the refraction of sunlight or moonlight through ice crystals, forming the particular kind of clouds which go by the name of *cirrus*. Such crystals behave like prisms, and the character of the halos depends upon the *definite* angles of the ice crystals or prisms. On the other hand, when one looks at the sun or moon through a mist or cloud, one often sees encircling rings, which are known as *coronæ*. The word, of course, is Latin for crowns. Their explanation, like the complete explanation of the rainbow, depends upon the undulatory or wave theory of light, but they differ from halos in that their radiuses are not constant. "The size of a corona depends on the size of the drops of water in a mist or cloud, being smaller as the drops are larger. Thus their diminution in radius shows that the drops are becoming larger, and implies approaching rain." The point is to contrast the *indefinite* size of the raindrops that cause the coronæ with the *definite* angles of the ice crystals, which cause halos.

Lenses. Having discussed the laws of refraction in general, and their application to spherical surfaces, we have seen them illustrated in one of the most remarkable phenomena of Nature, which has been a subject of wonder and legend from the earliest times. We must now pass, as we promised, to a more practical matter—the application of the laws of refraction in the various kinds of lenses. Of the more abstract parts of this subject, however, we cannot make a very adequate study, but we must do so to a sufficient extent to enable us to understand the most wonderful of all optical instruments, which is the eye, and also certain other instruments of man's construction, such as the microscope and the telescope.

The most familiar illustration of a lens, of course, is found in the pieces of glass which are put into spectacles. A lens may be made of glass or any other refracting medium. Glass is, of course, the most commonly employed. Much practical interest attaches, however, to the use of lenses made of other materials, which may behave otherwise than glass in relation to certain portions of what we have called the "ethereal keyboard." A piece of glass bounded by two plane surfaces is, of course, not a lens; one surface, at least, of a lens must form part of a sphere, or must, at any rate, be curvilinear. We confine our attention to lenses which have a definite curvature. When the curved surface is curved outwards or is convex, we have a convex, or converging lens. When it is curved inwards, or concave, we have a concave or diverging lens. We have already seen what is meant by a convergent, and what by a divergent pencil of light, and our knowledge of the laws of refraction is now sufficient for us to understand why the convex lens is said to be converging, and the concave lens diverging. One surface of the lens may be flat while the other is curved, thus giving us what is called a plano-convex, or a plano-concave lens; or a lens may have one surface convex and the other concave, as, for instance, in the case of a watch-glass. The simplest, perhaps, are those lenses which are commonly used for spectacles, and which have both surfaces either convex or concave. Such lenses are called doubly convex and doubly concave, or *bi-convex* and *bi-concave*.

Lenses and Mirrors. Each lens has an axis, and this, in the case of the bi-convex or bi-concave lens, is a straight line joining the centres of the two surfaces—that is, the centres of the circles of which the surfaces of the lens are parts. The reader must recall what has been said about mirrors in relation to a good many of the terms which are used of lenses. Thus a spherical mirror, like a lens, has an axis. Each also has a principal focus. When a pencil of parallel rays, such as those coming from the sun or a star, falls upon a convex lens in a direction parallel to its axis its constituent rays converge after passing through the lens and meet one another at a point beyond. This point lies upon the axis of the lens, and is known as its *principal focus*. The statement as to the convergence of the rays is not completely true. It varies from the truth just as does the similar statement which we made concerning the principal focus of a spherical mirror, and later we shall see its consequences.

But a bi-concave lens—or any concave lens—also has a principal focus. It is true that when a pencil of parallel rays falls upon such a lens they are caused to diverge, not converge. They will never meet one another. Nevertheless, if the lines of their new course be produced backwards through the lens again, such lines will meet at a point upon the axis. In other words, the rays, after passing through the diverging lens, will *appear to diverge* from a point on the axis. This point is called the principal focus of the lens and has the same significance as the principal focus of the convex lens, though it happen to lie on the opposite side. The distance between the lens and its principal focus, wherever that may be, is a very important fact about the lens, and is known as its *focal length*.

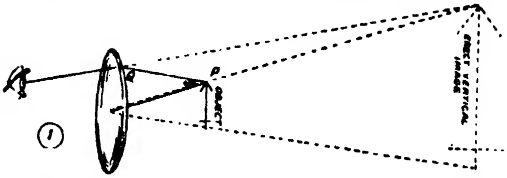
Having compared and contrasted convex and concave lenses, we note the simple fact that the divergent lens is thinnest at the middle, while the convergent lens is thickest at the middle. This is true of glass lenses in air, but these characters are interchanged when the refractive ratio is reversed, "as, for instance, when the lens is an air space surrounded by water." The laws of refraction explain this at once.

The Law of Lenses. Professor Tait summarises the whole matter in what he calls the following "excessively simple form": *A thin lens increases or diminishes by a definite quantity the convergence or divergence of all rays which pass through it.* "This quantity," he says, "is the divergence or convergence of rays falling on the lens from, or passing from it to, its principal focus. Or it is the convergence or divergence which the lens produces in parallel rays. Thus, if the distance of an object from a convex lens be twice the focal length of the lens, the image is formed at the same distance from the lens, and is equal in size to the object."

The reason why one has to say "a thin lens" is evident if one consider what happens in refraction at parallel surfaces. We know that when light passes through a pane of glass it emerges, not in its original direction, but parallel to it. In the case of a lens of any considerable thickness, this would introduce a new complication, but as a rule the thickness of a lens is very small relatively to its focal length, and so we may assume for practical purposes that rays which pass through the optical centre of the lens are continued in the same straight line. This optical centre is defined as a point found in every lens, lying in its principal axis, and such that every ray of light passing through it emerges in a direction parallel to its original direction. In the case of thin lenses, such rays are practically continued in the same straight line.

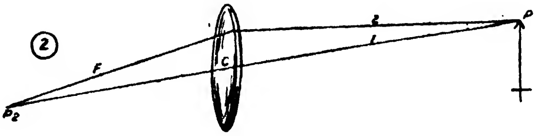
We are already familiar with the phrase *conjugate foci* as describing two points upon the principal axis of a spherical mirror so related that the rays upon either are brought to a focus at the other. Similarly, a pencil from any point near the axis of a lens converges on the other side of the lens to another point which is also near the axis. If the lens be concave, such a pencil is treated so that it appears to diverge from another point, similarly near the axis, but in this case on the same side of the lens. Such pairs of points in either case are called *conjugate foci*, and have the relation that the rays of a pencil from either will pass through the other in the case of the convex lens, or will appear to pass through the other in the case of the concave lens.

Convex Lenses and their Images. Anyone who has ever possessed a convex lens, such as are used in spectacles or are employed as simple microscopes, must have observed certain facts for himself which may here be briefly stated. Two kinds of images are produced by such a lens. The one is real and the other virtual. The one called *real* is so because the refracted rays have actually passed through the point which they appear to pass through. The virtual image is so-called because the refracted rays do not actually pass through the point, but merely appear to have diverged from it, as can be seen if the rays are produced backwards. In either case the size of the image varies directly as its distance from the centre of the lens. When we use such a glass as this as a simple microscope, we place the lens close to the body to be studied, and we obtain an upright image of the body, which is *virtual*. The body in such cases must be nearer to the lens than its principal focus. It is so near that the rays from it diverge greatly—so much so, that the lens, though a converging lens, is not able to destroy the divergence, but merely to lessen it. Says Professor Tait: "In using a hand magnifier in this way, we so adjust it by practice that the enlarged image appears to be formed at the distance from the eye at which vision is most distinct. It is obvious that the amount of magnification must then be greater as the focal length of the lens is less." This, of course, means, as we all know, that the most "bulgy" lens is the most powerful magnifier. The accompanying diagram—note what happens to the divergent ray PQ—shows what



happens in the production of a virtual erect image by a convex lens used in the fashion we have described—the essential point being that the object, the image of which is formed, lies nearer to the lens than its principal focus.

The Second Kind of Image. But, as every one knows, when we hold up such a simple microscope to the eye, we obtain a very small inverted image of distant objects. The reader should see this for himself with the aid of his glasses, if he be long-sighted, or by means of a simple microscope, if he possess one, or by means of one of the object glasses from the eyepiece of his microscope—a scientific instrument which, in its ordinary form, is inexpensive, and surely ought to be in the possession of everybody. Convex lenses are used for this purpose in various ways as, for instance, in the object glass of a telescope, as we shall see, and in the familiar and beautiful scientific instrument which is called the *camera obscura*. The accompanying diagram shows the conditions under which this real inverted image is formed. In order to find the position of the image of any point formed by a lens, such as the point P at the head of the arrow in our diagrams, one should begin by drawing two rays. The first is one which passes through the centre of the lens and has its course unchanged. The second is the ray which passes from the point P parallel to the axis of the lens, and, being parallel, is therefore refracted so as to pass through the



principal focus of the lens. In the accompanying diagram we have marked these rays 1 and 2. The point at which these rays coincide is the point where the image of P will be formed—that is, P 2 on the diagram. Once we have obtained the position of P we can then construct the remainder of the image, and the reader may be left to complete the diagram for himself.

The Microscope and Telescope. These facts are already sufficient to enable us to understand the principles of the ordinary astronomical telescope and the ordinary compound microscope. Thus, the fundamental part of the compound microscope is merely the simple microscope or convex lens which constitutes the part of the instrument near the object and is known as the *objective*. But let

us begin with the telescope; and first of all, a few words as to its history.

Here we cannot do better than quote from the authoritative life of Galileo, recently published by J. J. Fahie (John Murray, 1903). The telescope was invented accidentally in Holland, in October, 1608, thus: "As the story goes, an apprentice playing with spectacle lenses in the shop of one Hans Lipperhey, an optician of Middleberg, noticed that by holding two of them in a certain position a large and inverted view of objects was obtained. On hearing of this, the master fixed two glasses in a tube so that the weathercock on a neighbouring church spire could be seen apparently nearer and upside down." This toy was shown in his window, where one day it was seen by a nobleman, purchased, and presented to a prince. Lipperhey petitioned what corresponded to our Parliament for a patent right, and they suggested that he should make the instrument so that one could look through it with both eyes, which he did. Their idea seems to have been that the instrument would be useful in war. There are two other claimants, also Dutchmen; but the interesting fact is that the news of the discovery, *but no more*, reached Galileo in the next year.

Galileo's Claims. The following is a precise quotation of a letter written by the great genius to his brother-in-law: "You must know, then, that about two months ago" [*i.e.*, about June, 1609], "a report was spread here that in Flanders a spyglass had been presented to Prince Maurice, so ingeniously constructed that it made the most distant objects appear quite near, so that a man could be seen quite plainly at a distance of two miles. This result seemed to me so extraordinary that it set me thinking, and as it appeared to me that it depended upon the laws of perspective, I reflected on the manner of constructing it, and was at length so entirely successful that I made a spyglass which far surpasses the report of the Flanders one. As the news had reached Venice that I had made such an instrument, six days ago I was summoned before their Highnesses the Signoria, and exhibited it to them, to the astonishment of the whole senate. Many of the nobles and senators, although of a great age, mounted more than once to the top of the highest church tower in Venice, in order to see sails and shipping that were so far off that it was two hours before they were seen, without my spyglass, steering full sail into the harbour; for the effect of my instrument is such that it makes an object 50 miles off appear as large as if it were only five."

Galileo's Method. Subsequently, in the year 1623, Galileo defends his right to be considered an independent inventor of the telescope. The point is worth insisting on, and we will quote, from a book of his, a few of the more interesting and instructive sentences: "With this simple fact" [the report about the Dutchman], "I returned to Padua and reflecting on the problem I found the solution on the first night after my arrival. In the next six days I made a more perfect instrument. It may be said that the certitude of the existence of such a glass aided me, and that without this knowledge I would never have succeeded. To this I reply that without the information my thoughts may never have been directed that way; but that such information made the act of invention easier to me, I deny, and I say more—to find the solution of a definite problem requires a greater effort of genius than to resolve one not specified; for in the latter case hasard, chance, may play the greater part, while in the former, all is the work of the reasoning and intelligent mind. I, on the simple information of the effect obtained, discovered the same instrument, not by chance, but by way of pure reasoning. Here are the steps: the artifice of the instrument depends either on one glass or on several. It cannot depend on one, for that must be either convex, or concave, or plain. The last form neither augments nor diminishes visible objects; the concave diminishes them, the convex increases them, but both show them blurred and indistinct. Passing, then, to the combination of two glasses, and knowing that glasses with plain surfaces change nothing, I concluded that the effect could not be produced by combining a plain glass with a convex or a concave one; I was thus left with the two other kinds of glasses, and after a few experiments I saw how the effect sought could be produced. Such was the march of my discovery, in which I was not assisted in any way by the knowledge that the conclusion at which I aimed was a verity."

There are no details about the first telescope; but the second was only as strong as a moderately powerful pair of opera glasses. An opera glass is simply a pair of Galilean telescopes fixed together.

Images Formed by Concave Lenses. But before we can go any further, we must discuss the image formed by a concave lens, for it was such a lens that Galileo used as his eyepiece, and these lenses are still used as the eyepieces of opera glasses. A concave lens, such as short-sighted people use in their spectacles, yields an *upright* image which is *virtual.* Let the reader draw for himself a concave lens with a small arrow at some little distance, as in the previous diagrams. Let him then draw, as in the previous case, the two rays, one passing through the optical centre of the lens, and the other parallel to the principal axis of the lens. As in the previous case, the image of any point of the object from which we start, such as the image of the tip of the arrow, will be found at the intersection of these two rays. The ray parallel to the principal axis, when passing through the lens, is refracted in the direction of the thicker part of the lens, as the rule invariably is. The line of its new course must now be produced backwards until it reaches the axis of the lens at the point which is, of course, the principal focus. When the figure is completed, the reader will see why the image formed is smaller and erect, and why it is said to be virtual.

Continued

STOCK FOODS FOR CATTLE

Green and Dried Fodder. Brewers' Grains. Feeding Cakes. Meals and Maize. Straw Food. The Acorn

By Professor JAMES LONG

GREEN AND DRIED FODDERS

Grass. Where grass is of good quality, it stands first as a food for farm stock; not only providing a ration at less cost, but involving the employment of less labour [page 875]. It should, however, be young, and young grass is secured by the careful admixture of varieties which flower at different periods, and by the omission of those which are not appreciated by the animal and which are consequently left to grow old and tough. Constant grazing ensures young and tender herbage, while judicious manuring, the land being dry, or, if necessary, drained, equally ensures high quality. Grasses of identical varieties are found on soils of different types, and yet cows will milk heavily and fatting cattle increase rapidly in weight in one case, while neither will respond in the other. This difficulty may be largely obviated by the supply of dung or artificial manures, or by folding sheep which are fed with cake. Similarly, where livestock are turned out to graze upon poor pastures, good results will follow by the increase of their produce and the improvement of the herbage if they are simultaneously hand-fed with rich food. Ten pounds of good dried grass is equivalent in feeding value to 60 lb. of mangels or cabbage, and to 100 lb. of white turnips; hence the importance of ensuring quality both in the grass and in the hay produced from it. Grass enables a farmer to feed his stock upon green or succulent food throughout the entire year, while it may be employed in conjunction with green forage, roots, and cabbage.

It has been demonstrated that the feeding quality of grass may be largely increased by the aid of artificial manures, and to such an extent that sheep fed upon a pasture thus improved will produce mutton equally as well as if, when grazing on unimproved grass, cake is added to their ration. Pastures differ so materially in character and value that while a bullock will fatten upon one, it will starve on the other. This is in part owing to the inferiority of the soil and lack of manure, and partially to the fact that during the grazing season it suffers from drought. The grass produced in a meadow after the hay crop has been removed, although extremely useful, is of much less value than the first crop. For this reason, aftermath, or second-cut hay, possesses a diminished value. The yield of grass on a pasture varies from 5 to 12 tons per acre; the smaller yield of poor grass on unimproved land suggests the importance of manure in order to secure a maximum yield combined with high quality. Such a yield may feed four times the number of stock.

Rye Grass. This is frequently grown as a special crop, and, where possible, is manured with liquid manure after each cut, ensuring at least three crops in a season. In some cases, the soil being peculiarly adapted to its growth, the weights produced are enormous. Rye grass is one of the richest of green foods. Cows may be tethered upon either pasture, meadow, clover mixture or rye grass, care being taken not to give them too large an area.

Clover. This food is richer in albuminoids than grass, and is better adapted for horses, swine, and sheep than for cattle [page 940]. In the United States it is quite common to provide clover patches into which swine are turned to feed with good results. The practice of turning sheep into clover in this country in folds or even in fields is commonly adopted. When supplied to cattle, clover should be supplemented with a food rich in carbohydrates, such as maize meal, barley meal, or rice meal. When cut clover is supplied to horses, it should be allowed to wilt. A good plan is to cut it a day before it is required.

Trefoil. Trefoil is occasionally sown alone as sheep food, but a perennial plant of trefoil, whether in pasture or meadow, immensely improves its feeding value.

Lucerne (Fr. and Ger., *Luzerne*). This crop [page 1197], very largely grown in the United States (where it is known as "alfalfa"), Argentina, and the Continent of Europe, is adapted to the warmer districts and the deep, rich soils of this country. It is largely grown in the Eastern counties, from Norfolk to Kent, and provides one of the richest of foods for stock of all kinds. Nothing is more useful for horses, whether green or dry, but being rich in albuminoids, it may be advantageously supplemented with maize meal.

Well-balanced Rations. The following figures are suggested quantities of concentrated food which may be added with advantage to various green foods in order that the ration may be better balanced.

GREEN CROPS RICH IN ALBUMINOIDS.

Lucerne	100 lb.	add maize or rice meal	6 lb.
Sainfoin ..	125	,, ,,	4 ,,
Crimson clover	150	,, ,,	4 ,,
Vetches	125	,, ,,	6 ,,
Clover	140	,, ,,	4 ,,

GREEN FOODS NEEDING ADDITIONAL ALBUMINOIDS.

Cabbage	150 lb.	add cotton-seed meal	2 lb.
Italian ryegrass	100	,, ,,	2 ,,
Rye	125	,, ,,	2 ,,
Maize forage ..	150	,, ,,	4 ,,

As lucerne may be cut three times between May and September and still provide a fourth crop for grazing, it should be grown on every

farm suitable to its requirements. Although cattle and horses may be tethered upon it, it is better to cut what is required a day before it is supplied to stock. By the aid of lucerne, horses, cattle, and pigs may be stall or sty fed. In four cuts from 15 to 25 tons may be secured in a season.

Sainfoin (Fr., *Esparcette ;* Ger., *Esparsette*). This crop is largely grown as sheep food, especially on the chalks and soils rich in lime. It makes an excellent change for sheep, and is cut twice yearly, yielding from 14 to 17 tons of green forage per acre. The hay is well adapted for horses, and is relished by stock of all kinds.

Vetches or Tares (Fr., *vesces ;* Ger., *Futterwicken*). These are chiefly grown as horse and sheep food, sheep being folded upon the crops. Being rich in albuminoids, it is better adapted for both classes of stock when sown with a mixture of oats or rye, both of which enable it to stand up better. Winter vetches supply an early May green crop, while those which are spring sown are ready in autumn, so that the plant is available for a long period. Vetches should be consumed when young, inasmuch as they are more digestible, but never given to horses or cattle quite fresh. Where sheep are folded on the crop they should be gradually accustomed to it. Vetches, when given in medium quantities with other foods, add to the milking powers of the cows, and are relished by swine. When grown for seed, the straw, or haulm, being comparatively rich in albuminoids and carbohydrates, may be used for either cattle or horses with advantage. Vetch hay is seldom produced, but forms a substantial ration.

Maize (Fr., *maïs*). The experience of the writer, who has grown this crop during many seasons, is that it is one of the most valuable on the farm [page 1198]. On suitable land well manured and in a warm climate, from 20 to 35 tons per acre may be produced in a good season. The crop is cut and distributed among the cattle on the pastures during August and September. Maize is especially valuable in a season of drought, when it seems to thrive best. It may be cut up by the aid of a special chaff-cutter, and preserved in a silo for winter use. When green it is sweet, practically all edible if not too late cut, and, used with cotton-cake or bean meal, is most valuable for cattle, sheep, and swine. A 20-ton crop yields three times as much non-nitrogenous food as a 10-ton crop of vetches, although the yield of nitrogenous matter is much smaller.

Rye (Fr., *seigle ;* Ger., *Roggen*). Green rye, apart from its value as one of the earliest green crops of the year, is almost as rich a food as average meadow grass, and therefore assists in bridging over the season between winter feeding and summer grazing. It should be cut while young, and employed as a soiling or forage crop in the manger or on the pasture.

Rape, Coleseed, or Colza. This crop is largely grown as a sheep food, sometimes combined with mustard. Under good cultivation it produces a large yield, and being a rich food, with a high nitrogenous ratio, is well adapted to its purpose. It should not be given to cows in large quantities, owing to its liability to impart a flavour to milk.

Cabbage (Fr., *chou ;* Ger., *Kohl*). Although apt to cause looseness among stock, cabbage is one of the best of the bulky foods. It is much relished, a good milk producer, and when grown in the form of thousand-headed kale, forms one of the best and most economical of sheep feeds. A ration for cattle is from 40 to 50 lb. daily, but cabbage should always be given in conjunction with dry foods, which include at least one variety of an astringent character, such as cotton-cake or bean meal.

Comfrey. This forage plant is mentioned chiefly that it may be avoided. It has been much lauded as a prolific and economical cropper. Certainly it produces a large quantity of forage with little trouble, but the food is essentially poor, it is not relished by stock, and once planted, it is most difficult to eradicate.

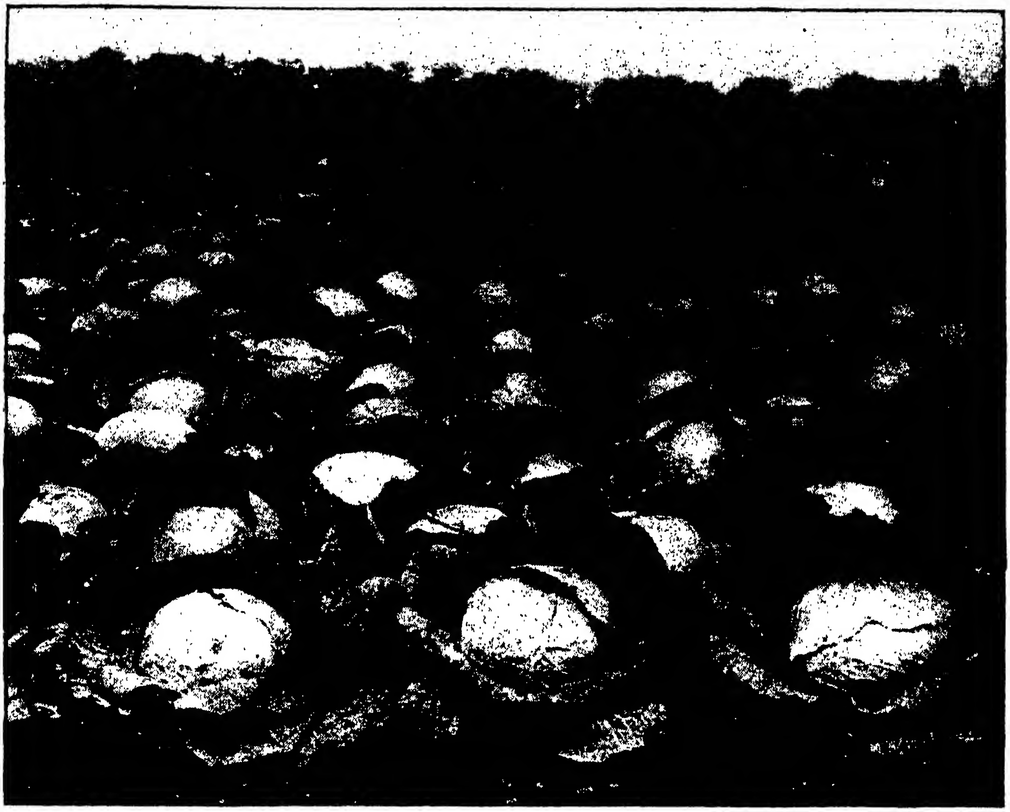
Gorse, Furze, or Whin. This well-known wild plant is really a rich food, but on account of its prickly character it must be bruised before it is supplied to stock. This is accomplished by the aid of a special machine known as a masticator. In districts where the supply is large, it forms an excellent addition to a winter ration on farms where forage crops of the best class do not grow with freedom.

Sorghum (*saccharatum*) is a substantial plant which succeeds in this country during hot summers. It somewhat resembles maize in the stalk, but it is much finer, and bears no cob. It is rich in carbohydrates, chiefly sugar, and owing to its sweetness and succulent character, is much relished by cattle. Sorghum, which is one of the millets, however, is quite an uncertain crop.

Potatoes. This popular tuber [page 945], although yielding a much smaller weight to the acre than mangels, swedes, or turnips, is much richer in nutritious feeding matter than the mangel, containing 20 per cent. of starchy matter. Where potatoes are largely grown, the unsalable or small tubers form an excellent addition to the ration of the pig or of cattle, cooked or uncooked ; 20 lb. a day are sufficient for a cow or bullock. We believe, however, that the most profitable method of utilising small tubers is to steam them for swine, and to use them in conjunction with skimmed milk and barley meal.

Carrots. On suitable soils large yields of this crop are produced, and form a most economical food. Carrots are highly relished by all classes of stock, and are especially valuable for cows and swine. For the former as much as 40 lb. a day may be given with advantage. They are rich in sugar, keep well, but should be fed in conjunction with the richer cakes and pulse meals. As many as 20 tons per acre may be produced on good, sandy loam.

Parsnips. These roots are similarly sweet and as nutritious as the carrot, both being superior to swedes and turnips. They form an advantageous addition to the ration of cows and



A CROP OF DRUMHEADED CABBAGES

pigs. They pay well to grow, and as many as 12 tons per acre are produced.

Mangels. This popular root [page 942] is one of those farm crops which are practically indispensable where stock is kept. It varies in quality, some varieties, like the smaller as compared with the larger roots, containing much more feeding matter than others. It is one of the greatest aids to the winter ration of cattle, for which it is pulped or sliced, and used in a mixture with other foods. It is valuable for swine and sheep, while the ploughman is glad to help himself to an occasional root for his horses. Feeding on mangels usually commences with January, while the bulbs, if carefully clamped, will keep until the following July. It is superior in feeding matter to the swede, especially when not grown to too large a size, for the bigger the mangel the smaller the percentage of the feeding matter, which largely consists of sugar. For fatting stock the globes and intermediate, or tankards, are preferred, while the long reds are often selected for milk production. Were mangel-tops dried on the principle adopted in Germany, where the tops of beet are dried for winter fodder, a valuable as well as an agreeable addition to the winter food of cattle would be secured.

Kohl-rabi (Fr., *chourave ;* Ger., *Kohlrübe*). We have in this plant a combination of the root and the cabbage, the flavour more closely resembling that of the latter plant. Kohl-rabi does not produce such large weights per acre as either cabbage or turnips, but it is a splendid change for stock, and is especially valuable in a dry season. Including the tops, the weight grown reaches from 25 to 30 tons per acre, although the average crop is much smaller, chiefly owing to insufficient manuring and imperfect cultivation. Rabi is an excellent food for dairy cattle, and may be used with some freedom inasmuch as it is not likely to impart its flavour to the milk.

Swedes (Fr., *rutabaga*) **and Turnips** (Fr., *navet ;* Ger., *Rübe*). These are two of the most extensively employed of succulent foods, although they are perhaps chiefly grown for sheep. Both are highly suitable for cattle, and both are usually pulped or sliced by machinery—a practice which is common for sheep which have lost their teeth, and for fatting and milking cattle. For cows the tops or crowns of the bulbs should be removed, as they impart a strong flavour to milk. Turnips, both white and yellow, are used early in the season, as they do not withstand frost, swedes being consumed next, as they are much hardier. Swedes are in most cases, especially in the southern half of England, eaten in the field by sheep as they stand, or, in case of hard frost, after being pulled up with a pick.

White turnips are inferior to yellow turnips as they contain slightly less sugar, while both white

and yellow are inferior to swedes, which contain 2 per cent. more sugar. Swedes, however, in their turn are inferior to mangels. The swede differs from the turnip as it possesses a neck, which is absent in the turnip. Both swedes and turnips are supplied to young stock which are being kept in store condition, although the quantity given to calves which have been weaned is at first but small. Fatting cattle receive large rations of both roots combined with chaff, meal, and cake.

Brewers' Grains. Although not a green food, grains may be included under the heading of succulent foods. They are at their best when sweet from the brewery, as they are more appetising, and less likely to spoil the flavour of the milk, for the production of which they are chiefly employed. In a good sample, the digestible matter present reaches about 13½ per cent., of which nearly one-third consists of albuminoids. They are cheapest in summer, when they are usually purchased by stock owners for pitting for winter use, but the process is followed by a change from the sweet to a sour condition, often bordering upon such advanced decomposition that they are really unfit for use. Unless the price is low and the distance to the brewery slight, it is questionable whether it is not more economical to use dry or desiccated grains which, by the addition of water, are practically brought to the condition of fresh, wet grains, and thus to obviate the necessity for so much haulage. Fresh grains contain about 76 per cent. of water, so that it is necessary to haul 3 tons of water to every ton of dry feeding matter. The summer prices of brewers' grains should not be higher than 3d. per imperial bushel, although it is usual to measure by the brewer's bushel, which holds much less as we have by actual test found to be the case. As compared with bran costing £5 a ton, grains at 4½d. to 6d. per bushel are an expensive food. Where wet grains are purchased by the ton, the water contained is usually excessive; in any case, however, we believe that desiccated grains will be found most economical between autumn and spring.

FEEDING CAKES

Linseed. Linseed is a food which is adapted for use only in small quantities, owing to its exceptionally high percentage of oil. The best method of preparing it for addition to a ration is that of steaming. The quantity required is placed in water in any suitable vessel, and the steam conveyed to it direct from a boiler; failing this, it may be boiled in water, and when the oil has reached a form of emulsion, it may be mixed with the food —chaff and meal—in the manger. It is well adapted for growing calves and young stock, and occasionally for cattle and horses, but only in very small quantities.

Linseed Meal. This is one of the most useful foods for young calves, being frequently employed as a milk substitute. It is cooked either in water or skimmed milk, and usually forms a leading constituent in all patent or composite calf foods.

Linseed Cake The most popular of all purchased stock foods is linseed cake, which is a by-product of the linseed oil mill. Linseed or flax seed provides two important products—the fibre and the oil, which reaches some 35 per cent. of the weight of the seed, although many samples contain either more or less; thus, in a bushel of linseed the oil averages about 18 lb. In the process of extraction some 8 to 12 per cent. of oil is left in the dry residue, which, pressed into cakes, is sold to farmers at prices varying from £7 to £9 per ton for the feeding of their stock. Under what is known as the new process of oil extraction by the aid of naphtha, the residue contains but a small percentage of oil—some 3½ per cent.—but slightly more albuminoids and carbohydrates. For fattening purposes and for calves, therefore, the old process food is undoubtedly better, but for general purposes, and especially for milking cows and store stock, the new process product, when the prices are relatively lower, will be found equally valuable, although there are differences of opinion, which experiments have not dissipated, as to the relative solubility of the albuminoids. It is probable, however, that cake made in the old way provides more digestible nutritious matter. Linseed cake is essentially a food for calves or young cattle and fattening beasts as well as for fattening sheep and lambs. In very small quantities it is useful for horses, as when given occasionally for putting on flesh and adding brilliance to their coats. For milking cows it is not equal to cotton cake. A sound cake, whatever its variety, should be at least 95 per cent. pure, and should be in sweet, sound condition, free from any adulterant and containing less than 2 per cent. of sand. Lawes found that the feeding value of stock foods advances from 8s. 7d. per ton in white turnips to £11 5s. for linseed cake.

Cotton-seed Cake. This product, also a residue or by-product of the oil mill, is made in two forms. We have first the raw cake containing the husk, which is tough and indigestible, and the decorticated cake, from which the husk has been removed. The husk contains some 1½ to 4½ per cent. of nitrogenous matter, but remembering its high percentage of indigestible fibre, it is unfit for food, and even dangerous when given to young stock in substantial quantities. The prepared kernels of the seed, which contain some 27 per cent. of oil, are heavily pressed for its removal, some 40 to 50 gallons being obtained from a ton of seed. According to Jordan the following figures represent the composition of cottonseed and its by-products after fairly complete separation.

	Water.	Ash.	Protein.	Fibre.	Carbohydrates.	Fat.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Cottonseed	9·9	4·7	19·4	22·6	24·0	19·4
Cottonseed Hulls ..	11·4	2·7	4·2			
Cottonseed Kernels ..	6·9	6·9		4·8	21·4	29·6
Cottonseed Cake .	8·6	7·0	44·1	4·9	21·2	14·2

The decorticated cake, which is bright yellow in colour and sweet and nutty in flavour, is much to be preferred, and although its cost is greater, it is distinctly more economical than the common cake. All pure cottonseed meals are similar to the best cake in these particulars. If tiny particles of the black husk are present in a meal, however, it is an indication that the husk has been finely ground and mixed with the pure meal. Cotton cake is neither used for horses nor swine, but it is a highly valuable food for fattening cattle and sheep owing to its richness in the three nutritious constituents of food, but in purchasing care should be taken to ensure, by guarantee, that the quality is good. Cotton cake may be mixed with linseed cake when necessary to moderate the laxative character of the latter. It is believed to influence the firmness of butter and the increased production of milk.

Other Feeding Cakes. Palm nut, rape, sesame, coconut, sunflower, and other cakes, which are chiefly used in continental countries, are little known in Great Britain. Rape cake, a by-product in the extraction of oil from rape or colza seed, is not relished by stock, although it is rich in oil and other feeding materials, a remark which applies in still greater degree to palm-nut cake, which is of a more agreeable character; to coconut cake, which is exceptionally rich in oil and digestible carbohydrates; and to sunflower cake, which, while containing less oil, is as rich as the best cotton cake in albuminoids.

Beans and Bean Meal (Fr., *fève;* Ger., *Bohne*). Bean meal, owing to its purity, which the feeder can so easily ensure, is much used in Scotland for milking cattle. The bean [see page 874] is extremely rich in starchy matter and albuminoids, but poor in fat. It is seldom economical to employ the home-grown bean for stock, inasmuch as the farmer can realise higher prices in the market than would warrant him in so doing; his best plan is to purchase foreign beans and to grind or crush them for use. Bean meal costing up to £7 a ton may be employed with great advantage for cows and feeding stock up to 4 lb. a day, while for sheep crushed beans in small quantities form a valuable addition to a mixed ration, Crushed or cracked beans, as we have shown in our reference to the feeding of horses, form a great help to the animal where the work is severe, while an occasional handful to store pigs is most advantageous.

Peas and Pea Meal (Fr., *pois;* Ger., *Erbse*). The pea [see page 874] is a food which is supplied to cattle and sheep, chiefly indeed to milking cows, in the form of meal in a mixed ration, and to the extent of 3 lb. or 4 lb. daily, and to swine with potatoes, and cracked or crushed in small quantities to sheep. Rich in albuminoids, peas form an invaluable addition to a ration, and although also rich in starch, crops grown upon the English farm are more profitably sold and replaced by samples of foreign or colonial origin.

Lentils. Lentils are not often obtainable, but when the price compares with that of imported peas or beans, they are a useful food in the form of meal, containing as they do similar proportions of albuminoids and carbohydrates and slightly more oil, but they should be clean and sweet. This is an important feature to remember in purchasing all varieties of imported pulse, and especially consignments from India and Egypt.

Barley and Barley Meal. Whole dry barley is supplied to poultry alone; but having been cooked or soaked, it may be given to pigs or cattle, although the practice is quite uncommon. Crushed barley is occasionally supplied to horses, although as a food it is inferior for their work to the oat. Barley meal, however, is commonly supplied to cattle, forming part of a mixture of the fattening ration. It is still more frequently used for swine either mixed with water or skimmed milk. Barley meal is often inferior, for it is generally produced from a poor husky foreign sample, mixed with other mill refuse which, ground to a state of flour, it is difficult to distinguish. The offal barley grown on the farm, when crushed, forms a useful addition to the feeding ration of sheep.

Malt. This food is slightly superior to barley, as well as more palatable, owing to its sweetness, which is occasioned by the process of conversion of starch into sugar. It is, however, for the farmer to determine when to use malt instead of barley, the price for a given weight being, perhaps, the chief factor.

Malt Sprouts or Combs. This is one of the most appetising of stock foods, and one which is especially rich in albuminoids, so that it may be employed with maize meal, roots, straw, and inferior hay, with great advantage. Here again, price determines how much and when to use a valuable feeding stuff.

Wheat and Wheat Meal. Apart from its being somewhat unsuitable as a stock food, wheat [see page 872] is too costly; but crushed, it may, if used in small quantities, form part of the rations of cattle and sheep, while it may be given whole to store swine, a handful at a time; or, when steamed or crushed, mixed with maize or barley meal. Under all conditions, however, wheat should be used with exceptional care, and the remark applies equally to wheat meal.

Bran, Pollard, and Middlings. These by-products of the mill, which have been largely deprived of the starchy matter of the wheat grain, are among the most valuable of stock foods. Bran is not only nourishing, but, being laxative, possesses a valuable physical influence. It is most palatable and sweet, and is consequently relished. It is rich in nutritious matter, of which it contains some 60 per cent., nearly 12 per cent. being albuminoids, so that it is naturally well-balanced. It is useful as an addition to cotton cake and the pulse meals, and when costing £5 a ton, is one of the cheapest foods on the market, but it should be pure and floury. Bran is specially advantageous as a ration in the form of a mash for cows at calving, or for ailing cattle and horses; but the feeder is cautioned against inferior samples, especially those produced in roller mills, some of which contain a high percentage of worthless husks or

fibrous matter, which is employed as an adulterant. The wheat offals known as pollard, middlings, blues, and dan, to which many other local terms are applied, vary in character, appearance, and quality, in a high degree. These foods may contain 57 per cent. of nutritious matter, including 11 per cent. of albuminoids, and 44 per cent. of carbohydrates, or they may reach 60 per cent. of the last named, as against 65 per cent. in the whole grain, and yet the best are approximately similar, or even superior in feeding value. The finer offals are more generally used for swine, especially sows and their young, than for stock of any other kind. Indeed, like wheat flour, they are too sticky in character and too costly to use in large quantities for cattle.

Oats and Oat Meal. Reference to the feeding value of the oat in the ration of the horse has already been made in the section upon horses [page 2074]. No food, however, is of greater value as a constituent of the ration of calves and young cattle in general, of lambs and adult sheep and of cows, but in all cases the grain should be crushed. The oat [page 873], however, is too costly as a common stock food, but ground oats, in which the constituents of the whole grain are present, are commonly employed for poultry, and but for its somewhat costly character might be advantageously supplied to calves and lambs, mixed with chaff and other foods. Oat hay—*i.e.*, the dry oat plant which has been cut before ripening, and consequently containing all the nourishment of the grain and the straw—is excellent fodder for horses and cattle, but it should be cut into chaff.

Maize. Although maize varies in price, sometimes falling as low as 13s. a quarter of 480 lb., and at others reaching 26s., it is one of our most important feeding stuffs, owing to its weight per bushel and its richness in nutritious matter, of which it contains some 80 per cent. Maize, however, is poor in albuminoids, which it is therefore essential to add in some other form. Maize meal is chiefly used for cattle and swine, crushed or cracked maize for sheep and horses, and cooked maize for fattening pigs. A material known as *Maize Germ Meal*, costing about £5 per ton, is now largely used, owing to the fact that it is exceptionally rich in fat and albuminoids, although it is the residue after the extraction of most of the oil. Next to the two layers of the outside husk of maize, which is chiefly fibrous in character, is a covering of cells which are especially rich in gluten. This gluten forms the chief constituent of two foods which are now commonly used in the United States, but which have but recently found their way into this country. Jordan points out that *Gluten Meal* comes from the flinty portion of the maize kernel, while the *Gluten Feed* is composed of a mixture of the hulls and the gluten. Gluten meal is extremely rich in nitrogenous matter, while both gluten feed and maize germ meal contain a high proportion of the same valuable constituent.

Rice Meal (Fr., *riz ;* Ger., *Reis*). Rice meal is exceptionally rich in starch, of which it contains from 47 to 55 per cent., the albuminoids varying from 8½ to 11 per cent., and the oil from 8½ to 14 per cent., although it is doubtful whether the oil of rice can be regarded from a nutritious standpoint in the same light as the oil of cereals and cakes. In any case, rice is rich in feeding matter, and, at its average price, one of the cheapest foods on the market, when pure. Impurity, however, is by no means an uncommon feature in this material, and the buyer should at all times guard against it.

Straw. Wheat straw is commonly employed when cut into chaff for horses and cattle, but among the cereals it is inferior to oat straw, containing less of each of the three nutritious constituents of food. *Oat straw* is softer, probably more digestible, and better adapted for stock, both in its long and short cut condition. There are, however, still doubts, as shown by each investigation which has been made, as to the proportion of straw which is digestible, and consequently valuable as a nutrient. *Rye straw* is too tough and too valuable for other purposes to be employed as an economical food, while *barley straw*—we refer to the winter variety—is not only inferior to other straws, but is an irritating material when employed for food or litter, and its use is often followed by the presence of insect parasites. The straw of summer barley is much superior to that of winter barley. The haulm, or straw, of *peas, beans*, and *vetches* is richer—bean straw in particular—in albuminoids than the straw of the cereals, while the other constituents are practically analogous. The straw, or haulm, of all the pulse crops—and the remark equally applies to the chaff, or husks and cavings—should be carefully preserved as animal fodder. The husks of the cereals closely resemble the straws from which they are derived in their feeding properties.

Various Other Foods. The *acorn*, so largely consumed in autumn by cattle, sheep, and pigs, and for which farmers are accustomed to pay from 6d. to 1s. a bushel to those who gather them, is a highly astringent food, containing only 38 to 40 per cent. of nutritious matter, chiefly carbohydrates, and it is questionable whether the risk involved in its employment is not greater than the benefit derived. It is, however, almost impossible, where oak-trees abound, to prevent cattle and sheep at liberty consuming them at will. The *locust bean* is exceptionally rich in sugar, its other food constituents being very small. This is a valuable aid, when supplied in small quantities, to a nitrogenous ration, or to any ration which it is desirable to make more palatable. The *artichoke*—where large quantities can be produced at little cost—is a useful food, slightly less nutritious than the potato.

Continued

continued from page 2089

FOLDING AND IRONING

How to Iron Table-linen, Serviettes, Cloths, Collars and Cuffs, etc. Glossing, Bleaching, and Bran Washing

By ALICE E. MARSHALL

Table-linen. Place the cloth on the ironing table, with the right side uppermost, and the hems at each side. If the cloth is a large one it may be folded, and each fold ironed separately. A fairly heavy iron—a No. 8 flat iron is a convenient size for the purpose—is required in order to obtain a gloss. The iron must be hot and perfectly clean. A small piece of wax wrapped in thin calico should be used to rub it on, to prevent it from sticking.

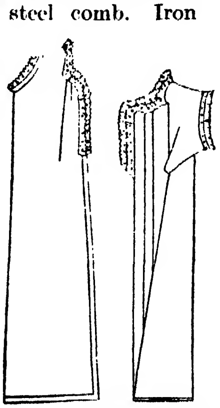
Tablecloths must be ironed on the right side only, until perfectly dry. To fold the cloth, place the selvedges together, with the right side inside, draw back the top half to the centre fold, and fold the bottom half back again underneath. This brings the cloth into four folds, the right side outside. Begin at the narrow end, roll the cloth up and tie with tape, or fold into a small compass. The cloth must be aired well before it is put away, or it will lose its gloss and be very limp.

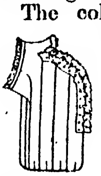
Serviettes. Serviettes are ironed in the same way, except that both sides must be ironed, the right side first, in order to obtain the gloss. They are folded in what is called the "screen" fold. Fold over one-third of the serviette, right side outside, so that any number or initial is in the top right-hand corner; fold back the remaining third underneath, and repeat this from left to right. In folding table-linen, a hot iron should be used to press the folds and so keep them in place.

Crochet and Netted Doyleys. Iron the centre part on both sides, then the work on the wrong side only, pressing out the edges with the toe of the iron; or the centre part may be ironed, and then the doyley be pinned out by the worked part on a board, and left until dry.

Fringed Tray Cloths. Comb out the fringes well with a small steel comb. Iron on both sides of the cloth and fold in four (right side inside), then turn back one corner to show any embroidery or initial. All embroidery or fancy work must be ironed on the wrong side only, to raise the design, and to prevent any gloss appearing on the right side.

Body-linen. In ironing body-linen, the small parts should be done first, such as frills and embroidery, the latter on the wrong side only. All bands and yokes must be ironed on both sides in order to dry them well, as they are generally very thick. After these, the body part of the garment can be ironed, taking the toe of the iron well into all gathers, and drying each part well. It is necessary to iron nearly all body-linen double. Care must be taken not to crease the under part, which should first be well smoothed out, whilst ironing the top half.





13. EXAMPLES OF FOLDING

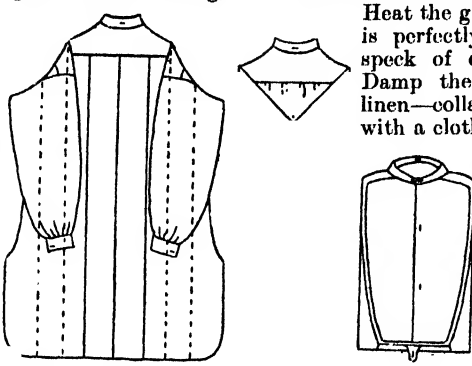
A nightdress or chemise, after ironing, may be folded by the "front fold," which shows the upper half of the garment, or by the "side fold," which only shows one half of the front. The latter, which we illustrate, is the simplest method [13]. Fold the garment in half, the side seams together; arrange the fulness in even pleats from the neck band or yoke, pressing each flat with a warm iron. Turn over the shaped piece at the sides until of an even width; fold upwards from the bottom three or four times, then turn so as to show the frills or embroidery on the front. Nightdress sleeves must be pleated up inside the garment, a small piece at the wrists being left to turn over on the front. All frills are improved by being goffered before the garment is put away. For this a goffering iron is necessary; it costs about tenpence, and is heated by being placed in the gas or fire. The iron, when heated, must be tested on a piece of cotton before using.

Goffering. To goffer, take up a small piece of the frill between the prongs of the iron and turn over to the right, drawing back the frill with the left hand whilst so doing. This must be done with the garment lying flat on the table; the heat of the iron and pressure forms the "goffer." Work from right to left until all the frills have been done, keeping an even distance between each "goffer." Should there be two or more frills, one above the other, begin with the one farthest from the edge, so as to avoid crushing those that are finished.

Collars and Cuffs. Before ironing collars and cuffs, they require to be starched. The articles, as already pointed out, must be perfectly clean and dry, and should have all the old starch removed from them. They must be boiled to remove the old starch, as washing alone is not sufficient.

The cold starch should be made according to the directions previously given. One tablespoonful of starch is sufficient for six collars, or four collars and one pair of cuffs. Stir the starch well from the bottom of the basin; dip the articles in,

one at a time; squeeze them out of the starch, and rub them well between the hands to get the starch into the folds, and repeat the process of starching and rubbing to make sure that this is done. Place the starched things separately on a clean cloth, and roll them up tightly; allow them to stand for two or three hours if possible in a cool place before ironing, as they can be ironed much more easily and smoothly if this is done.


(a) (b) (c)
14. EXAMPLES OF FOLDING

When ironing, take one collar or cuff out of the cloth and place it flat on the ironing table; wipe each side with a clean cloth to remove any specks from the linen, at the same time pushing any fulness from the top to the bottom; a bone paper-knife may be used with good effect. Have ready a clean hot iron, rub it on the wax to prevent it from sticking, and test the heat of the iron on a piece of calico. If too hot, it will cause the linen to "mackerel," that is, it will cause numerous small creases which cannot be removed. If too cold, the linen will not be stiff, as the heat of the iron is not sufficient to cause the starch grains to burst. Iron lightly on the wrong side of the collar or cuff two or three times, then heavily on the right side, pressing out the creases; iron on both sides until perfectly stiff and dry.

To Curl Collars. Place an iron on the left-hand side of the collar, and pull the collar sharply from underneath it, pressing the iron downwards with the right hand. If done quickly, the collar will "curl" as desired.

Shirts. Prepare the starch as for collar and cuffs; dip the cuffs into it, holding the hand tightly on the sleeve above them, to prevent the starch from going into it; wring out the cuffs, and rub the starch well into the linen; repeat the process, and starch the shirt front in the same way, taking care that the starch does not go into the body part. Place the cuffs on the front, roll them up tightly, and let the shirt lie for two or three hours in a cool place.

In ironing a shirt, first iron the neckband and yoke on both sides, then the cuffs and sleeves; then fold down the centre of back, and iron on both sides. Iron the front of the shirt on the back, putting a pleat down the latter. Place the shirt-board underneath the linen front, and iron the front carefully, drying it well; gloss the front and cuffs, and fold and air well. Fig. 14 shows how a shirt should be folded.

Blouses are ironed in practically the same way. If stiff collars and cuffs are desired, they must be starched with cold starch.

How to Gloss Linen. Various preparations are sold which are said to give a gloss to linen. One, a glossing block, is rubbed over the starched articles before they are ironed. But care should be taken when these are used, as they generally consist of some chemical preparation which is very inflammable, and the linen is easily scorched and discoloured. The best method is to use a glossing iron. This is a small iron cased with steel, and costing about 1s. 3d. No. 1 is the best size to use.

All the linen should be ironed before glossing. Heat the glossing iron, and see that it is perfectly clean, for the slightest speck of dirt will spoil the result. Damp the outer fold only of the linen—collars are generally fourfold—with a cloth wrung out of cold water; place the collar or cuff on a hard surface—a board is generally used—and with the heel of the glossing iron rub quickly and heavily over the surface, one way only, until it is bright and polished. Unless the article has been well ironed, and is quite free from all specks, it is useless to attempt to gloss it; it only makes the defects more noticeable.

Laces. White lace should be first steeped in cold borax water—one tablespoonful of dissolved borax to one quart of water. Wash it in warm water with melted soap, squeezing, but not rubbing it, between the hands gently. Then rinse it in clear, warm water. Stiffen it with thin boiled starch, or rice water, made by boiling a tablespoonful of rice in one pint of water until the latter has a milky appearance, then straining the liquid and using as required. In the case of silk lace, gum water should be used. Fold it evenly, place it between a cloth, and mangle it. Iron it on the wrong side only, pressing out the points with the toe of the iron. Maltese and Honiton lace should not be ironed, but should be pinned out carefully by the pattern on a board, and left until dry. Chiffon may be washed as lace; if put into a wide-mouthed bottle with a soap lather and well shaken, much handling may be avoided. Iron at first with a cloth over.

White Silk and Ribbon. If very dirty, steep the silk in cold water, as the lace. Wash it in warm soap lather—avoid cracking the grain if the silk is corded—squeeze it between the hands, or scrub it gently with a soft brush. Rinse it in clean water to which blue may be added if desired. Stiffen it by using one dessertspoonful of gum water to one pint of cold water. The same amount of methylated spirit may be added to increase the brightness of the silk; then place it between a cloth and mangle.

Iron silk with a cloth over it at first; if the iron comes in direct contact with the damp silk, it will stick and leave a brown mark. Only a moderately hot iron should be used.

Coloured Silks. Coloured silk and chiffon may be washed as white, with these exceptions. Add salt to the steeping and rinsing water. Steep it a few minutes only in cold water. The

water should be nearly cold for washing and rinsing. One tablespoonful of vinegar may be added to the rinsing water to revive the colour.

Quick washing and rinsing are necessary to preserve the colour, and, in addition to these precautions, the silk or chiffon must not be allowed to remain damp, but must be ironed immediately after it has been washed.

Black ribbon or lace may be washed in strong tea, a little melted soap being added if the article is very dirty. Rinse it in tea to which has been added a little gum water. Iron the silk or lace with a cloth over to avoid glazing it.

Gum Water. To make gum water, add one ounce of gum arabic to half a pint of cold water. Place the crystals in a jar with cold water; stand the jar in a saucepan half full of water, and let it simmer gently on the fire until the gum is all dissolved; strain it through a piece of muslin into a bottle, and use as desired. From one teaspoonful to one tablespoonful may be added to a pint of cold water, according to the stiffness desired. The gum arabic may be bought from any chemist, and costs from 1d. to 4d. an ounce. The cheaper quality may be used if strained well after it has been dissolved.

Bran Washing. Embroidered linen and canvas, particularly the unbleached varieties, may be washed in bran water, which gives them a slight stiffness and helps to retain their natural shade

Add one breakfastcupful of bran to two quarts of cold water; boil it for about ten minutes, removing the scum which rises; strain and add one quart of cold water, and use for washing and rinsing the materials. A little soap jelly may be added to the water in which the articles are washed if they are very dirty. Rinse them in bran water, squeeze them out, fold and mangle. Iron quickly on the wrong side whilst damp.

Bleaching. Clothes which have become a bad colour may be bleached by being put out in the open air in powerful sunshine or frost. They must be kept damp, as the sun has more power over them in this condition. Bleaching agents are sometimes used, but great care is necessary to see that the material is not injured.

To prepare chloride of lime for bleaching, mix a quarter of a pound of chloride of lime with one quart of cold water; place it in a large jar, and let it stand covered for a day or two, stirring it occasionally, and then straining it through a piece of fine muslin into a bottle. Use in the proportion of two tablespoonfuls to one pint of water. Pour out the mixture without shaking any sediment at the bottom of the bottle. Dip in the article to be bleached and hang out wet in the open air; repeat the process if necessary, but do not let the article lie in the bleaching preparation, or the material will be destroyed.

Curtains, flannelette, etc., are rendered less inflammable if alum is added to the rinsing water.

Continued

Thomas à Becket. Richard Cœur de Lion. John and Magna Charta. Development of Europe. Charlemagne

Continued from page 2676

By JUSTIN McCARTHY

HENRY II. was now a young man, but he was well qualified in strength, in nerve, and in purpose to be a sovereign at such a time. He was capable of incessant work, had a passion for business, a resolute determination, and looked carefully into every question brought before him for settlement. He was the more popular among his people because he was a great hunter and lover of all manly sports.

Ambitions of Henry II. He endeavoured to draw Englishmen and Normans together into a single nation. He did his best towards the removal of those feudal divisions between ranks and classes which had so long been a heavy restriction on the growth of liberty and of agricultural and mercantile prosperity. He had strong convictions as to the power of the sovereignty, and was as devoted in his maintenance of the throne as in contempt for feudal institutions. He was quite ready to make either the nobles or the Church subservient to his own ideas of good government. He did his best to establish legal, judicial, and administrative systems which should carry out his own projects; but outside this purpose he was not a thinker, and he appears to have had no consciousness of the great changes which were going on in thought and feeling during his time. He had no religious devotion, and he regarded the Church as an institution which he might make useful in carrying out his plans of national cohesion and of strong and widespread empire. For a long time he had the assistance of Theobald, Archbishop of Canterbury, and with his help he did much to clear the land from the invasions of marauders, and to destroy their strongholds, in spite of the

in fact, to such an order themselves. He restored some of the great courts of law to something like a condition of judicial independence.

Thomas à Becket. Thomas à Becket succeeded to the Archbishopric of Canterbury, and became the personal friend and supporter of the sovereign. It does not appear that the Archbishop was able to win his sovereign from any of his designs for an extension of his monarchy in France, where he already owned vast dominions. But he did his best to prevent the King from carrying out such designs. He also strongly opposed the change which the King intended to introduce into the power of the Church, a change which was meant to put all legal jurisdiction into the hands of the sovereign himself. A long and impassioned struggle now set in between the King and the Archbishop of Canterbury. The object of the sovereign was to reduce the whole ecclesiastical jurisdiction of the country into subjection to the Royal will, and the object of Thomas à Becket was to maintain the Church as an independent and religious power. The King was as persevering in his movement of aggression as the prelate was in his resistance. The modern reader of history will probably think that the King and the prelate alike pushed too far their opposing claims, and that the idea of an omnipotent monarch or an omnipotent Church in England was not to be reconciled even with the vague ideas of political and religious freedom which were then beginning to be spread abroad. In the long disputes between Henry and the Archbishop the Pope was on many occasions disposed to accept Henry's views, and did his best to bring the Archbishop into a reconciliation with the King. But the prelate remained indomitable, and at last King Henry began to regard the presence of Thomas à Becket as intolerable.

The end of the struggle was a ghastly tragedy. While the King was in Normandy he heard of fresh resistance to his will offered by Thomas à Becket, and Henry is said to have lost all self-control, and demanded passionately how it happened that among all the knights who surrounded him and ate his bread there was none who would rescue him from this turbulent priest. Four of his knights, all bearing Norman names, are supposed to have heard the words, and they at once quitted Normandy, and, journeying to England, entered Canterbury Cathedral on December 29th, 1170, in the dusk of the evening, and put the Archbishop to death before the altar of Saint Benedict. Thomas à Becket was canonised by the Church authorities at Rome soon after his death.

of

King carried on the struggle with the Church and the barons throughout his reign. The fortunes of war were varied, but on the whole Henry's policy was successful. One of the most momentous events of Henry's reign was his invasion and conquest of Ireland. We have already seen in considering the history of Ireland how the idea of this invasion was suggested to Henry, and how he invaded Ireland and made it a part of the English dominions. The King spent some time in Ireland organising the country according to his own principles of constitution making. He divided the land into counties, laid the foundations of a reasonable system of law, and established courts of justice on foundations which have ever since maintained their hold. But he also endeavoured to establish feudalism as it had existed in England, and to abolish the land tenure system between chieftains and people; and he put in force a plan to confiscate the

lands held on the old terms between the Irish chiefs and people in order to effect a settlement of his Norman followers on Irish soil.

Whatever may have been Henry's mistakes and wrongdoings, he undoubtedly did much to found that system of constitutional rule which has, notwithstanding disastrous interruptions, been growing more and more with the centuries in England. Henry was not fortunate in his family affairs. His eldest son had died in childhood, and his second son, Henry, born in 1155, was in 1170 designated his father's successor. This son and his brother Richard rebelled against their father not long after, receiving the support of the King of Scotland and the King of France. The King of Scotland, called William the Lion, was defeated when he invaded the North of England, was taken prisoner, and to obtain his liberty made submission to Henry. During one of these rebellions Prince Henry died, and another son, Geoffrey, was killed in a Paris tournament. While Henry was engaged in another war with the King of France, his son Richard took sides with the French sovereign, and Henry's favourite son, John, followed the example of his brother. These events are believed to have been too much for the exhausted King's endurance, and he died in France in July, 1189, aged 56 years.

Richard the Lion-Hearted. The death of Henry II. left the throne open for one of the most famous English sovereigns known to history, around whom has grown up a very world of romance in poetry and prose such as even King Arthur himself and his Knights of the Round Table have hardly been able to import into our literature. The new sovereign was Richard I., Cœur de Lion, the third son of Henry, born at Oxford on September 8th, 1157. He was crowned King of England, Duke of Normandy, and Count of Anjou in 1189. Richard had spent most of his childhood and boyhood in France, and, indeed, during the whole of his life, which was but a short one, he was only to be found at rare intervals in the country over which he ruled. By the advice and urgency of his mother he was prevailed upon, while only a boy in years, to join his brothers Henry and Geoffrey in their revolt against their father. Sixteen years later he joined in a league with Philip Augustus, King of France, and again helped to make war on his father. When Richard succeeded to the throne he had already taken the vows of a Crusader, and he decided that he must do his duty as Crusader first and leave his work as sovereign of England for a later period. Richard underwent many adventures on his voyage to the Holy Land and his march towards Jerusalem. He never was fortunate enough to enter the Holy City, but he won some splendid victories over Saladin, the sovereign of Egypt and Syria. He captured Acre and several fortresses on the south of Palestine, and at length concluded a three years' peace with Saladin by a treaty which it was hoped would lead to some arrangement which the Christian sovereigns could accept with regard to Jerusalem and the Holy Land.

Richard and Normandy. Then Richard set out for England, and met with many adventures. He was shipwrecked; he had to make his way in disguise through the dominions of his enemy Leopold, Duke of Austria; he was recognised and captured, and had to obtain a heavy ransom from England to purchase his release. He then reached England, and was generous enough to forgive his brother John, who had done his best to injure him. The remainder of Richard's life was spent in warring against the King of France, Richard striving to get possession of Normandy, and the French sovereign striving to put an end to foreign rule over that part of France. Richard was killed in April, 1199, by a shot from an arrow while laying siege to the castle of Chaluz.

The reign of King Richard made no great mark on the condition of the country over which he ruled. He was one of the most picturesque of sovereigns, his many generous and noble qualities contrasting strangely with his moods of savagery, coarseness, and cruelty. He was a gallant soldier, a daring, but not often a merely reckless military adventurer; and he might have proved himself a statesman and a benefactor to his country if he had not been occupied for the greater part of his reign in foreign war.

The majority of modern English readers probably know Richard Cœur de Lion best as they find him in romance. Sir Walter Scott has made him one of the leading figures in "Ivanhoe," and given us there a lifelike impersonation of Richard in his more chivalrous and generous moods.

King John. Richard was succeeded by his brother John, a strange contrast in every sense. John, the youngest of the five sons of Henry II., was born at Oxford in December, 1166. After the conquest of Ireland John was sent there by his father, and endowed with the title of King. Although still a youth he conducted himself so badly in Ireland that he had to be recalled, and he next signalised himself by endeavouring to seize the crown while King Richard was in Austrian captivity. Richard, when dying, designated John as his successor.

The accession of John greatly hastened the loss of Normandy to England, a loss which only brought about the end of a dominion impossible of endurance, which could have accomplished no real benefit either to the French province or its English masters. Owing in great measure to the manner in which John exercised his sway the Normans began to discover that they were more of kin to the people of France than to the people of England. The French King invaded Normandy, and John found it impossible to hold out against the invaders and their gradual coalition with its native population. He came back to England, and opened there the most important chapter of his reign—one of the most important chapters of any English reign. John's reign called into existence that first great charter of England's liberty—Magna Charta.

Much personal homage cannot be rendered to the memory of King John because of this work accomplished during his reign. John had little sympathy with the principle of national liberty. His whole nature was steeped in vices of the worst order—he was sensual, wantonly cruel, systematically deceitful; in one mood a slave to mere superstition, in another an embodiment of sceptical cynicism. But he was undoubtedly a man of much ability, of remarkable reading for a sovereign of his time, with a keen capacity for getting safely through a perplexing crisis. He was still anxious to recover his Norman dominion, and was making extensive preparations for an expedition with that object. But he met with a strong opposition on the part of many of his own barons and prelates, and on the part also of Pope Innocent III. At the same time John had to renew his war with Philip of France, and thus to prepare for a formidable struggle at home and abroad. The opportunity was given to the barons, the clergy, and the people to demand that John should fulfil his early promises, and restore the constitution which had been framed by Henry I.

Signing of Magna Charta. The King displayed his usual skill in discovering the best way out of a difficulty, and though he at first refused, yet when preparations for war actually began, he saw that the time had come for him to give way and assume the part of a patriot King. He summoned the barons to a conference at Runnymede, on the Thames between Staines and Windsor, and there the great charter was discussed and agreed to on the 15th of June, 1215.

The charter was a development of that introduced by Henry I., but it was developed into something like a complete constitution, and from it have grown all the political, legal, and civic systems which have since secured to the English people the development of their freedom. The courts of law, the rights and securities of municipal institutions, the arrangements of shires and counties, and the independence, rights, and privileges of Parliament were set out in this great charter. There were yet struggles to be gone through at home and abroad before the charter obtained its final settlement, for the Pope issued an interdict against it, and some of the English barons took his side and called in the aid of France. John fell ill of fever while the crisis was still on, and died at Newark on the 19th of October, 1216. The settlement of the charter was, however, soon to be accomplished, and seldom in history has so great and enduring a reform been effected by a sovereign who had so little natural inclination to promote the cause of constitutional liberty and order.

Development of Europe. We have now to bring up the development of European history to that period of time reached in our survey of England's progress. We pass from England to the Continent, and naturally begin our study of Continental States with France. We have already said something of France as she appears through the dawn of history. She was occupied from that dim period by a number of tribes belonging to various races who had found a settlement on her attractive soil, and among whom the Celtic Gauls were the largest in numbers and held the greater part of the land. The Romans conquered a large part of the country some two centuries before Christ, and Julius Cæsar came to hold an almost complete mastery over Gallia, or Gaul—the France of all modern history.

Early History of France. The Gauls began rapidly to adopt Roman principles of government, Roman manners, and even the language of Rome, for the French tongue is obviously derived directly from Latin. For many centuries France continued to be a prosperous and progressive province of the Roman Empire; but as the power of Rome declined, the Teutonic race began to pour in upon the soil of France. The Teutons were pressed by the invasions and occupation of foreign tribes whom the fertile regions of the Rhine attracted, and consequently had to seek new realms to occupy. There were various settlements of the same character by different races, and each invading people came to found a kingdom of its own. The Burgundians took possession of the fruitful plains watered by the Rhone, and established the kingdom of Burgundy, while the Goths settled down on both sides of the Pyrenees. The Franks were now the most powerful and dominant people in France, and under their sovereign, Clovis (481–511 A.D.), made themselves masters of a large territory, and after a while made as much of Paris as then existed their capital.

Clovis became a Christian, and unquestionably prepared the way for the future kingdom of France. Owing to his zeal in the interests of Christianity, he obtained the title of "Most Christian King," a title which passed along during many centuries to the sovereigns of France. It happened thus that a Germanic race gave to France not only its first dynasty of kings, but even the name by which the country has ever since been known. The invaders adopted the language of the invaded, the semi-Latin tongue which was spoken in France, and the other invading tribes in those parts followed their lead.

Charlemagne. The first really powerful French sovereign—a man famous in all history—was Charlemagne, son of Pepin, commonly called "the short," King of the Franks and founder of the Carlovingian dynasty. Charlemagne was born in April, 742 A.D., and, with his brother, Carloman, succeeded to the joint occupation of the sovereignty on Pepin's death in 768, and on the death of Carloman, in 771, became sole King of the Franks, bearing also the title of Roman Emperor. He carried on many wars against the Saxons, and became a strong supporter of Pope Adrian I., on whose invitation he crossed the Alps and reduced some Italian regions to submission to the Papal authority. He went into Spain to contend against the Arabs and the Moors, but had to return to France to crush some new Saxon risings. He spread his dominions over much which since became the Austrian Empire, and went again

into Italy to support Pope Leo III. against the Romans, who had risen in rebellion. It was for this service that he was crowned by the Pope, and received the title of Emperor of the Romans in 799.

Conqueror and Statesman. Charlemagne was a great statesman as well as a great military commander; he was also a scholar, a promoter of education, and a patron of letters and arts. He did his best during his reign to make his great Empire a consolidated, peaceful, and progressive State. But there are many evidences that Charlemagne, during the later years of his life, was convinced that so vast and so incoherent an empire could hardly hold together under any one ruler. Before his death he divided his realms among his sons, in the hope that such an arrangement might give to each ruler a fair chance of holding his own State in security.

It is as an evidence of the manner in which the renown of Charlemagne had spread over the world that Haroun al Raschid, the famous Eastern potentate whose name is familiar to all modern readers in the pages of the "Arabian Nights," sent ambassadors to the Court of the great Frankish sovereign with messages of respect and admiration. Charlemagne died on January 28th, 814, and was buried at Aix-la-Chapelle. He is stated to have been the author of valuable collections of projected laws, and also of many Latin poems. His fame will always live, but the great empire he founded did not long outlast his time. The sons of Charlemagne were utterly unequal to the task he had bequeathed to them, even in the moderated and qualified form in which he had left it. Charlemagne had endeavoured to leave to the peoples whom he conquered their own laws and their national and local customs, hoping that by this means he might all the more thoroughly hold them together as the component parts of one great empire.

The Empire of Charlemagne. Charlemagne was in this much in advance of his time. The general idea of conquerors, even in more modern days, has been that a great number of subjugated States can most securely be kept together by compelling them to adopt the laws and usages of the conquering power. The world is now beginning to recognise that empires are best consolidated by the recognition of local usages and laws. But Charlemagne did not live long enough to give his own principles of government a fair chance. There was at that time strongly at work throughout Europe an impulse towards the splitting up of conquest-created States into their separate nationalities; and it is doubtful whether the empire of Charlemagne could, under any conditions, have remained for any length of time a living reality. Thus the whole country continued very much as in older days—divided among a number of chiefs or kings, all acknowledging the more or less imaginary leadership of some supreme ruler, each occasionally making war on the other, and endeavouring to become master of as many others as his strength and opportunity would allow.

Hugh Capet. The real founder of French Royalty through a long continuous history was Hugh Capet, Count of Paris and Orleans. Hugh Capet had risen to great influence in the State, and when the monarchy founded by Charlemagne was falling to pieces in the hands of his successors, the feudal chiefs of the country elected Hugh Capet king in 987. The new sovereign was to be the one and only sovereign of the whole country, and with his election ended the Frankish rulership, which had practically died with Charlemagne. Hugh Capet and his successors had their residence in Paris, and were crowned at Rheims, thus illustrating the principle that the Rhine divided the monarchy of France from the Germanic races. Paris was then declared to be the capital of all France, whereas in former days the locality of the capital depended very much on the inclinations or the nationality of the sovereign. From this time downward we can follow the progress of the French monarchy as the one ruling institution of the country, until we come to the days when the monarchical system in France received its sudden interruption by the outbreak of the French Revolution.

Now, for the first time, France settled down into the form of one cohesive State, owning and maintaining one distinct nationality, and regarding any foreign intrusion across her boundary lines, when it came under the sanction of a foreign ruler, as an invasion which the united power of all the French provinces was alike bound to resist. Many foreign invasions and systems of sovereignty, and of other rule, will yet have to be described; but from this epoch France is ever the one France, the one nationality, the one great State.

Continued

Continued from page 2778

SPANISH

Continued from page 2770

By Amalia de Alberti

PRONOUNS

Personal. The personal pronouns in the nominative are:

Singular.	*Plural.*
yo, I	*nos*, *nosotros*, we
	nosotras (fem.)
tu, thou	*vos*, *vosotros*, you
	vosotras (fem.)
él, he, it (mas.)	*ellos*, they
ella, she, it (fem.)	*ellas*, they (fem.)
usted, you	*ustedes*, you

1. *Tu* is used in familiar intercourse, and should be translated *you*, except where *thou* would be admissible in English; its plural is *vosotros*.

2. *Nos* is only used in the nominative, as the official *we* of public bodies, etc.

3. *Vos* is only applied to one person, and is now rarely used, except in prayer or in addressing royalty. It loses the *v* in the accusative—Example: *Señor, os suplicamos*, Lord, we beseech you.

4. *Usted* represents the conventional *you* of ordinary intercourse. It is an abbreviation of *vuestra merced*, your Grace, and is always abbreviated in writing to *V* or *Vd*, plural *V.V.* or *Vds.* *Usted* is counted as the third person; its repetition in a sentence is avoided by the substitution of pronouns of the third person. Example: *Cuando he visto á Vd esta mañana le dijo*, When I saw you this morning, I told you.

There are two forms of personal pronouns in the dative and accusative cases, one to be used with a preposition and one without.

ACCUSATIVE WITHOUT PREPOSITION.

Singular.		*Plural.*	
me, me		*nos*, us	
te, thee		*os*, you	
le-lo	you / him / it	*los*	you / them
la	you (fem.) / her / it (fem.)	*las*	you (fem.) / them (fem.)

The dative differs from the above in having only *le* and *les* for both genders in the third person. It may be translated with the prepositions *to*, *for*, or *from*, and may thus be distinguished from the accusative. Examples:

ACCUSATIVE.

Lo quiére, I like him
La quiére, I like her
Los quiéren, I like them
Las quiéren, I like them (fem.)

DATIVE.

Le habló, I spoke to him *or* her
Le dió, I gave him, *or* to him, *or* her
Le compró, I bought him, *or* for him, *or* her
Le quitó, I took from him *or* her
Les envió, I sent them, *or* to them, *or* to you

To avoid ambiguity, a double pronoun is sometimes used. Example: *Le habló á él*, I spoke to him; *le habló á ella*, I spoke to her.

For the sake of euphony, *se* is substituted for the dative *le* and *les* when these are followed by another pronoun beginning with *l*. Example: *Dale el libro, ya se lo he dado*, Give him the book; I have given it to him.

It is best to use *lo*, the mas. singular, in the accusative for things to which no gender is assigned in English, and *le* for anything which would be masculine in English. Examples: *¿Conoce Vd á este hombre? Si, le conozco*, Do you know this man? Yes, I know him. *¿Ha leido Vd este libro? Si, lo he leido*, Have you read this book? Yes, I have read it.

The neuter pronoun *ello*, *lo*, it, applies only to abstract things which take the neuter article *lo*, as already explained. Example: *Ello puede ser verdad, pero no lo creo*, It may be true, but I do not believe it.

Reflexive. To these pronouns may be added the reflexive pronoun *se*, used as a substitute for pronouns of the third person in all cases but the nominative. *Se* is invariable in gender and number; in the direct objective it means himself, herself, etc. Example: *Se ha lastimado*, He has hurt himself; *se han marchado*, They have gone.

NOTE. The nominative pronoun is nearly always suppressed in Spanish; the literal translation of the last sentence would be *they have gone with themselves*, or in the familiar English phrase, "taken themselves off."

ACCUSATIVE AND DATIVE WITH PREPOSITION.

The forms to be used with a preposition are *mi*, *ti*, *si*, *él*, *ella*, *Vd*, *nosotros*, *vosotros*, *ellos*, with their feminines. Examples: *Ese traje es para mí*, That dress is for me; *que haya amistad entre ellos y Vds*, Let there be friendship between them and you; *se acudieron á mí y á él*, They had recourse to me and to him.

With the preposition *con*, with, *mi*, *ti*, and *si* form one word and assume the termination *go*: *conmigo*, with me; *contigo*, with thee; *consigo*, with himself, herself, etc.

With other pronouns, *con* follows the general rule: *con él*, with him; *con nosotros*, with us.

1. Both forms of pronouns are sometimes used in one sentence to increase the emphasis, but

this makes no difference to the wording in translation. Example:

Me parece, It seems to me

Me parece á mí }
Á mí me parece } It seems to me

2. Pronouns generally precede the verb, but with the infinitive, present participle, and imperative without negation, they are affixed to the verb, forming one word. Examples: *Me ve,* he sees me; *verme,* to see me; *viendome,* seeing me; *le digo,* I tell him; *díme,* tell me.

3. When two pronouns occur, one in the dative and the other in the accusative, the dative is placed first. In the above cases, both are affixed to the verb. Examples: *Daselo,* give him it. In the imperative with negation, the pronoun is not affixed to the verb. Example: *No creed lo,* do not believe it.

4. The pronoun may also be affixed to other tenses when the verb begins the sentence. Examples: *Gústanme mucho los ingleses,* I like the English very much; *encontróles en casa,* I found them at home.

Vocabulary	**Vocabulario**
Love	Amor
Friendship	Amistad
Indifference	Indiferencia
Hate	Odio
Repulsion	Repulsion
In love	Enamorado
A friend	Un amigo
A person who hates	Una persona que odia
Repulsive	Repulsivo
Ire	Ira
Anger	Cólera
Impatience	Impaciencia
Patience	Paciencia
Vengeance	Venganza
Bad feelings	Malos sentimientos
Kindness	Bondad
Amiability	Amabilidad
To pardon	Perdonar
The navy	La marina
The Royal Navy	La marina real
The merchant service	La marina mercante
A steamer	Un vapor
A frigate	Una fragata
A merchant vessel	Un buque mercante
The compass	La brújula
The capstan	El cabrestante
The rigging, cordage	Las jarcias
The hatchway	Las escotillas
A hammock	Una hamaca
Ballast	El lastre
The flag	El pabellon
A paddle wheel	Una rueda de paleta
An oar	Un remo
A port-hole	Una porta
A sounding lead	Una sonda
The powder magazine	El pañol de la pólvora
The helm	El timon
A sail	Una vela
An admiral	Un almirante
A vice-admiral	Un vicealmirante
A rear-admiral	Un contraalmirante
A captain	Un capitan de navío
A lieutenant	Un teniente.
A midshipman	Un guardiamarina
A pilot	Un piloto
A lighthouse	Un faro
Literature	(La) literatura
A writer	Un escritor
A historian	Un historiador
A novelist	Un novelista
A poet	Un poeta
A journalist	Un periodista
A newspaper	Un periódico
A daily paper	Un diario
A pamphlet	Un folleto
A bachelor of arts	Un bachiller
A master of arts	Un maestro de artes
A translator	Un traductor
Medicine	La medicina
A doctor	Un doctor
A surgeon	Un médico
A specialist	Un especialista
An oculist	Un oculista
An operation	Una operacion
Surgical instruments	Los instrumentos de cirujía
A dentist	Un dentista
A toothache	Un dolor de muelas
To draw a tooth	Sacar una muela
An abscess	Un absceso
False teeth	Dientes postizos

Exercise VII. (1)

Translate the following into Spanish:

1. Love does not hide itself. 2. You are in
.....no.......oculta.................
love with the daughter of your neighbour.
.................................vecino....
3. Yes, sir, and I told her so yesterday. 4. She is
.................dije....ayer.............
indifferent to you. I do not believe it. 5. Do
indiferente .... No
not be impatient; patience is a virtue. 6. A
tenga ....virtud .....
person who hates seeks vengeance. 7. Those
.... busca ....
are bad feelings, have kindness, and pardon.
.... tenga ....perdone.
8. The captain, besides being a sailor, is a writer.
.... ademas ....
9. The doctor of whom I spoke to you is a
.... quien .. hablé ....
specialist but is not an oculist. 10. They have
.... han
stolen his surgical instruments. 11. He has not
robado.......................... No tiene
got toothache, because his teeth are false. 12.
....
The journalist is a poet; his newspaper is a very
....
well written daily.
.... escrito .....

Exercise VII. (2)

Translate the following into English:

1. Le habló, y él no escuchó. 2. Dále el pan. Yá se lo he dado. 3. ¿ Conoce Vd á esta mujer ? La conozco. 4. No es verdad, no lo creo. 5. Se ha lastimado, llama al médico. 6. Se han marchados, llámenlos. 7. Me parece que odia á ese hombre. 8. Encontrólos en su casa de Vd y pelearon.

PROSE EXTRACT VI—concluded

From "El Diablo Cojuelo" ("The Lame Devil"), by Luis Velez de Guevara.

DON CLEOFAS AND THE LAME DEVIL VISIT THE MADHOUSE.

"There is a gentleman's servant who took up service though he had enough to eat. There is a dancer, left dancing aimlessly to no music. Further on is a historian who went mad with grief for the loss of three decades of Livy. Beyond is a canon, surrounded by mitres, trying which suits him best, for he took to saying that he was bound to be a bishop. In that other cell, seated on a coffer full of doubloons, secured with three locks, is a rich miser, who, having no child nor relation to inherit from him, leads (himself) a wretched life, by being a slave to his money. The man singing in that other cage is a musician; he is confined in this prison for crimes against good sense, because he was always singing, but stopped whenever he was pressed to sing. This is a piece of impertinence common to nearly all members of that profession. In that poor little lodging in front is a married demon who was driven mad by his wife's temper." Then Don Cleofas said to the companion who was showing him all these miserable objects: "Let us get out of this before they arrest us for some form of madness unknown to us, for in this world we are all mad, one against the other."

DON CLEOFAS Y EL DIABLO COJUELO VISITAN LA CASA DE LOCOS.

"Alli está un criado de un señor que teniendo que comer se puso a servir. Alli está un bailarin que se ha quedado sin son bailando en seco. Mas adelante está un historiador que se volvió loco de sentimiento de haber perdido tres decádas de Tito Livio. Mas adelante está un colegial cercado de mitras, probandose la que le viene mejor, porque dió en decir que habia de ser obispo. En esa otra celda, sobre un cofre lleno de doblones cerrado con tres llaves esta sentado un rico avariento que sin tener hijo ni pariente que le herede se dá muy mala vida, siendo esclavo de su dinero. Aquel que canta en esa otra jaula es un músico; está preso en esta carcel de los delitos del juicio porque siempre cantaba, y cuando le rogaban que cantáse dejaba de cantar. Impertinencia es esa casi de todos los de esta profession. En aquel pobre aposentillo en frente esta un demonio casado, que se volvió loco con la condicion de su mujer." Entonces don Cleofas le dijo al compañero que le enseñaba todo este retablo de duelos: "Vámonos de aquí no nos embarguen por alguna locura que nosotros ignoramos, porque en el mundo todos somos locos, los unos de los otros."

Luis Velez de Guevara (1579–1644), dramatist and prose writer. "The Lame Devil," first published in 1641, is a short, satirical story, in which a student escaping over the roofs of some houses, enters the attic of a magician, where he finds the Lame Devil imprisoned in a bottle, and sets him free. In return the Devil carries him through the air to different parts of Spain, unroofing the houses for his amusement.

Le Sage re-wrote the story in French in 1707, acknowledging its Spanish origin, and made it world-renowned under the title of "*Le Diable Boiteux.*"

Luis Velez de Guevara (1579–1644) dramatista y escritor. "El Diablo Cojuelo," publicado por vez primera en 1641, es una historia corta y satírica, en la cual un estudiante escapándose por encima de algunos techos de casas entra la guardilla de un mágico endonde encuentra al diablo cojuelo prisionero en una botella, y lo liberta. En cambio el diablo lo lleva por el aire a diferentes partes de España, destechando las casas para divertirle.

Le Sage volvió a escribir la historia en Frances en 1707, reconociendo su origen español y la hizo célebre en el mundo entero bajo el titulo de "*Le Diable Boiteux.*"

KEY TO EXERCISE VI. (1).

1. El banquero y su socio están hablando con el corredor acerca del contrato. 2. El tenedor de libros está haciendo las cuentas para el fin de año. 3. Este caballero tiene una carta de crédito sobre nuestra casa. 4. Tengo un pagaré á la orden de £10,000 esterlinas. 5. Para ser un buen pintor, grabador, ó escultor es preciso ser un buen dibujante. 6. Puede uno ser un buen músico y no saber cantar, y cantar bien sin ser músico. 7. Las zarzuelas españolas son mas bonitas que las inglesas. 8. Las óperas italianas son mas amenas que las alemanas, y las francesas las mas alegres.

KEY TO EXERCISE VI. (2).

1. Five hundred young men, and four hundred women left their native land. 2. A couple of friends quarrelled. 3. The company lost a million dollars. 4. The bank will open on the first day of the year. 5. The loan will be paid on the 8th day of the month. 6. The clerk has written a hundred times. 7. Give me the half of a loaf. 8. I will give six loaves and a half.

Continued

ITALIAN

Continued from page 2772

By Francesco de Feo

NUMERICAL ADJECTIVES

A. Cardinal Numbers

0 zero (*dzèhro*)
1 uno (*oòno*)
2 due (*doòeh*)
3 tre (*treh*)
4 quattro (*kooàhttro*)
5 cinque (*cheèn-kooeh*)
6 sei (*sèhee*)
7 sette (*sehtteh*)
8 otto (*òtto*)
9 nove (*nòveh*)

10 dièci (*dee-èhchee*)
11 ùndici (*oòndee-chee*)
12 dòdici (*dòdee-chee*)
13 trèdici (*trèhdee-chee*)
14 quattòrdici (*kooahttòrdee-chee*)
15 quìndici (*koo-eèndee-chee*)
16 sèdici (*sèhdee-chee*)
17 diciassètte (*dee-chee-ahssèhtteh*)
18 diciòtto (*dee-chee-òtto*)
19 diciannòve (*dee-chee-ahnnòveh*)
20 venti (*vèhntee*)
21 ventuno (*vehntoòno*)
22 ventidùe (*vehntee-doòeh*)
23 ventitrè (*vehntee-trèh*)
24 ventiquattro, etc.
30 trenta (*trèhntah*)
40 quarànta (*koo-ahràhntah*)
50 cinquànta (*cheen-koo-àhntah*)
60 sessànta (*sehssàhntah*)
70 settànta (*sehttàhntah*)
80 ottànta (*ottàhntah*)
90 novànta (*novàhntah*)
100 cento (*chèhnto*)
200 dugènto (*doo-dgèhn-to*)
300 trecènto (*trehchèhnto*)
400 quattrocènto (*koo-ahttrocènto*)
500 cinquecènto (*cheen-koo-ehchèhnto*)
600 seicènto (*seh-ee-chèhnto*)
700 settecènto (*sehtteh-chèhnto*)
800 ottocènto (*otto-chèhnto*)
900 novecènto (*noveh-chèhnto*)
1,000 mille. (*meèlleh*)
2,000 duemìla (*dooeh-meèlah*)
3,000 tremìla (*treh-meèlah*)
4,000 quattromila, etc.
10,000 dièciмila
50,000 cinquantamila
100,000 centomìla
1,000,000 milione, etc.

1. The cardinal numbers are indeclinable, except: *uno* (one), which changes into *un*, *una*, *un'* (see the indefinite article), and *mille*, which changes into *mila* when preceded by any other number. (See the irregularities in the plural of nouns.) Example: *Un soldo*, a halfpenny; *una lira*, a franc; *due mila uòmini*, two thousand men.

2. The compound numbers *ventuno*, *trentuno*, *quarantuno*, etc., require the following noun to be in the singular. But if a noun precede these numbers, the noun is made plural. Example: *Quarantuno cavallo* (41 horses), but *cavalli quarantuno*; *ventuna lira* (21 francs), but *lire ventuna*. Compound numbers after 21 may be written in two separate words: *venti due*, *venti tre*, *trent' otto*.

Cento may be shortened into *cen* in compound numbers, when it is not before an accented syllable. Example: *Cencinquànta* or *centocinquànta*, *trecendiciotto* or *trecentodiciòtto*, *cenquarànta* or *centoquarànta*, etc.; but *centovènti*, *centosètte*, *centodièci*, etc., and not *cenvènti*, *censètte*, *cendièci*, etc.

Cento and *mille* are not preceded by the indefinite article, as in English: *Io ho cento quarantadue libri*, I have one hundred and forty-two books.

NOTE. *Io ho un centoquaranta libri* means: I have *about* one hundred and forty books. In expressions like: From four hundred to five hundred, it is not necessary in Italian to repeat the word *cento*. Example: *Da quattro a cinquecento libri; da sette a ottocento lire.* Twenty-five, twenty-six, etc., are always rendered in Italian by *venticinque*, *ventisei*, etc., and never *cinque e venti* (five-and-twenty); *sei e venti* (six-and-twenty).

3. To indicate the hours of the day, cardinal numbers are preceded by the article *le*, except *l'una*, one o'clock.

NOTE. The article *le* is referred to the feminine plural *ore*, which is always understood: *sono le sei* = *sono le ore sei*, It is six o'clock.

The hours of the day are now counted from 1 to 24; but they may be also counted as in English.

un' ora (*oonòrah*), an hour
mezzo, *un mezzo* (*mèhdzo*), half, a half
mezz' ora (*mehdzòrah*), half an hour.
mezzogiorno (*mehdzo-dgee-òrno*), *mezzodì* (*mehdzo-deè*), noon, midday.
mezzanotte (*mehdzah-nòtteh*), midnight
un quarto (*oon koo-àhrto*), a quarter
un quarto d' ora, a quarter of an hour
minuti (*meenoòtee*), minutes
secondi (*sehcòn-dee*), seconds

The hours of the day are indicated as follows:
Che ora è? Che ore sono? What time is it?
A che ora? At what time?
È l' una, è il tocco, it is one o'clock.
All' una, al tocco, at one o'clock.
Sono le due, le tre, le quattro, etc., it is two, three, four, etc., o'clock.
Alle due, alle tre, alle quattro, etc., at two, three, four o'clock.
Sono le due, le tre, le quattro, etc., *e mezzo*, it is half-past two, three, etc. (Lit., (they) are the two and a half.)
Alle due, alle tre e mezzo, at half-past two, etc.
Sono le due, le tre e un quarto, it is a quarter past two, past three, etc. (Lit., and a quarter.)
Alle due, alle tre, etc., *e un quarto*, at a quarter past two.
Sono le due, le tre meno un quarto, it is a quarter to two, to three, etc. (Lit., less a quarter.)
Alle due, le tre meno un quarto, at a quarter to two, etc.
Le otto, le quattro, le sette, etc., *meno cinque*, *meno dièci* (*minuti*), five, ten (minutes) to eight, to four, etc.
Le ùndici, le otto, etc., *e cinque* (*minuti*), *e dièci* (*minuti*), etc., five (minutes) past, etc.

B. Ordinal Numbers

1st primo (*preèmo*)
2nd secondo (*sehcòndo*)
3rd terzo (*tèhrtso*)
4th quarto (*koo-àhrto*)
5th quinto (*koo-eènto*)
6th sesto (*sèhs-to*)
7th sèttimo (*sèhtteemo*)
8th ottavo (*ottàhvo*)
9th nono (*nòno*)
10th dècimo (*dèh-cheemo*)
11th undècimo, or decimoprimo
12th dodicèsimo, or decimosecòndo
13th tredicèsimo or decimoterzo

14th quattordicèsimo, or decimoquarto
15th quindicèsimo, or decimoquinto
16th sedicèsimo, or decimosesto
17th diciassettèsimo, or decimosèttimo
18th diciottèsimo, or decimottavo
19th diciannovèsimo, or decimonono
20th ventèsimo (*ventéhseemo*)
21st ventunèsimo, or ventesimoprimo
22nd ventiduèsimo, or ventèsimosecondo
30th trentèsimo (*trehntèhseemo*)
40th quarantèsimo, etc.
100th centèsimo (*chenhtèhseemo*)
101st centunèsimo, or centesimoprimo
102nd centoduèsimo, or centèsimosecondo
1,000th millèsimo (*meellèhseemo*)
1,001st millèsimoprimo, etc.
1,002nd millèsimosecondo
1,003rd millèsimoterzo, etc.
1,000,000th milionèsimo, etc., etc.

1. The forms *decimoprimo, decimosecòndo*, etc., are used to indicate succession of monarchs, popes, centuries, as: *Luigi Decimosesto; Leone Decimoterzo; ventesimo sècolo*, etc. Roman figures are used as in English: *Luigi* XVI, *Leone* XIII, *secolo* XX.

2. The days of the month, *il primo* excepted, are expressed by cardinal numbers, as: *Roma*, 24 *marzo* (Rome, March 24th); *Londra*, 21 *aprile*, 1906 (London, April 21st, 1906). In phrases like: On the 8th of April last, on Monday next, on Tuesday, etc., *on* is not translated in Italian.

Note that the names of the months and of the days of the week are not written with capital letters.

3. Ordinal numbers form their feminine and plural like other adjectives, as: *la prima casa, la dècima casa, i primi studi*, etc.

THE DAYS OF THE WEEK.

domènica, f m. (*domèhneeca*), Sunday
lunedì (*looneh-deè*), Monday
martedì (*mahrteh-deè*), Tuesday
mercordì (*mehrcor-deè*), Wednesday
giovedì (*dgee-oveh-deè*), Thursday
venerdì (*vehnehr-deè*), Friday
sàbato (*sàhbahto*), Saturday

THE MONTHS.

gennaio, January	*luglio*, July
febbraio, February	*agosto*, August
marzo, March	*settembre*, September
aprile, April	*ottobre*, October
maggio, May	*novembre*, November
giugno, June	*dicembre*, December

Pronounced: *dgehnnàh-eeo, fehbbràh-eeo, màhrtso, ahpreèleh, màh-dgee-o, dgee-oò-neeo, loò-leeo, ahgòsto, sehttèhmbreh, ottòbreh, novèhmbreh, deechèhmbreh.*

C. Collective Numbers

pàio (*pàh-eeo*), a pair; (plural, *paia*, fem.)
còppia (*còppee-ah*), a couple.
una decina (*dehcheè-nah*), about ten, half a score.
una dozzina (*dodzeè-nah*), a dozen.
una quindicina (*koo-eèndee-cheènah*), about fifteen.
una ventina (*vehnteè-nah*), a score.
una trentina (*trehn-teè-nah*), about thirty.
una cinquantina, etc. (*cheen-koo-àhnteènah*), about fifty.
un centinaio (*chehnteenàh-eeo*), a hundred; (plural, *centinàia*, fem.).
un migliaio (*mee-lee-àheeo*), a thousand; (plural, *migliàia*).
tutt' e due (*tootteh-doòeh*), both.
tutt' e tre (*tootteh-trèh*), all three.
tutt' e quattro (*tootteh-koo-àhttro*), all four.
tutt' e cinque (*tootteh-cheèn-kooeh*), all five, etc.

NOTE. *Tutt' e due, tutt' e tre, tutt' e quattro*. etc., must be followed by the article, as: *tutt' e due i fratelli*, both brothers, etc.

The forms *ambo, ambedue, entrambi, amendue, ambidue*, and similar terms for *both*, are no longer used.

D. Multiplicative Numbers

sèmplice (*sèhmpleecheh*), simple.
dòppio (*dòppeeo*), double.
triplo (*treèplo*), three-fold, triple.
quàdruplo (*koo-àhdrooplo*), four-fold.
quintuplo (*koo-eèntooplo*), five-fold.
sèstuplo (*sèhstooplo*), six-fold.
dècuplo (*dèhkooplo*), ten-fold.
cèntuplo (*chèntooplo*), a hundred-fold.

Note also the forms *triplicato, quadruplicato, centuplicato*; and the forms *dùplice, trìplice, quadrùplice, settèmplice, centùplice.*

E. Distributives

a uno a uno, one by one.
a due a due, two by two.
a tre a tre, etc., three by three.
a dièci a dièci, ten by ten.
a venti a venti, twenty at a time.
a cento a cento, etc., one hundred at a time, etc.

Note also the forms: *a uno, a due, a tre*, etc., and *a uno per volta, a due per volta, a tre per volta*, etc., one at a time, two at a time, etc.

EXERCISE XVI.

1. Cinquanta lire. 2. Cinquantuno cavallo. 3. Ecco la nota della lavandaia: camicie ventuna, colletti quarantuno, fazzoletti ùndici. 4. Una lira sterlina è venticinque franchi. 5. A Maratona dièci mila Greci sotto il comando di Milziade sconfissero cento mila Persiani. 6. Nell' ùltima battàglia i nostri nemici perdèttero tremila uòmini. 7. Siamo in casa il mercordì e il venerdì. 8. I mesi di gennaio, marzo, maggio, luglio, agosto, ottobre, dicembre hanno trentun giorno, febbraio ha ventotto giorni, gli altri trenta. 9. L' anno ha quattro stagioni: primavera, estate, autunno, inverno. 10. Tarquinio il Superbo fu il sèttimo e ùltimo re di Roma. 11. Per adesso mio figlio ha solamente duemila lire l' anno, ma fra due o tre anni avrá quasi il dòppio. 12. Luigi XVI fu decapitato nel gennaio 1793. 13. Sono le otto e mezzo e il treno parte alle nove e cinque.

CONVERSAZIONE.

Siete mai stati in Italia?

Parècchie volte, ma non siamo mai stati a Nàpoli (*non.. mai = never*).

Noi partiremo per la Frància il sette aprile e ritorneremo il quìndici o il venti maggio.

Che ora è? Ho un appuntamento con un amico al Caffè Colonna alle dièci precise (exactly).

Oh, allora. avete ancora molto tempo, sono appena le otto e un quarto.

Chi ha avuto il primo prèmio ?

Non so (I do not know); mio fratello ha avuto il secondo premio e mio cugino il terzo.

Possiamo entrare ? (May we go in ?)

Sì, ma entrate a uno per volta, senza far rumore, perchè il nonno è malato.

Venite con noi al Costanzi stasera ? Abbiamo un palco di prima fila (a box in the first circle).

Se avrò tempo, verrò alla fine del secondo atto.

Key to Exercise XIV.

1. My father and my mother. 2. His Majesty the King. 3. His Royal Highness. 4. Their Majesties. 5. Their uncle is the first gentleman-in-waiting (literally: first waiter-of-honour) of his Holiness Pio X. 6. I have bought a nice present for the birthday of my sister. 7. My grandfather is eighty years old. 8. This hat is not mine; you have taken mine, and I have taken yours. 9. Books are our best friends. 10. That friend of yours is very kind. 11. My money is as good as yours. 12. They are right; but I am not wrong. 13. His (or *her*) mother hopes to be in Paris to-night. 14. Do not be envious of other people's good fortune. 15. Let only the enemies of thy country be thy enemies. 16. If we had had time we would have gone to the theatre with your aunt. 17. With your help, we hope to have our money back.

Key to Exercise XV.

1. A few chapters. 2. Some novels. 3. Too many mistakes. 4. How many people! 5. Every evening. 6. Every man has his faults. 7. A gentleman has sent several presents for Miss Maria. 8. With little money certain persons succeed in living well (lit., to live well). 9. Every man has his own tastes. 10. All men are brothers, and therefore they must love one another. 11. Some say that we are right, and others that we are wrong. 12. Every effect has its causes, and no cause is without an effect. 13. My brother and sister have gone into the country; our old father is always at home; some friends remain with him all the evenings. 14. Where are your friends? 15. Some in France, others in Italy. 16. Every boy shall have a present. 17. If the lawyer does not have his money within a certain time, the contract will be void. 18. Some men think they deserve all our respect, only because they have a great deal of money.

Continued

FRENCH

Continued from page 2776

By Louis A. Barbé, B.A.

Être, To Be.

Indicative.

Simple Tenses.

Present.

I am, etc.

je suis	*nous sommes*
tu es	*vous êtes*
il, elle est	*ils, elles sont*

Imperfect.

I was, etc.

j'étais	*nous étions*
tu étais	*vous étiez*
il, elle était	*ils, elles étaient*

Past Definite.

I was, etc.

je fus	*nous fûmes*
tu fus	*vous fûtes*
il, elle fut	*ils, elles furent*

Future.

I shall be, etc.

je serai	*nous serons*
tu seras	*vous serez*
il, elle sera	*ils, elles seront*

Compound Tenses.

Past Indefinite.

I have been, etc.

j'ai été	*nous avons été*
tu as été	*vous avez été*
il, elle a été	*ils, elles ont été*

Pluperfect.

I had been, etc.

j'avais été	*nous avions été*
tu avais été	*vous aviez été*
il, elle avait été	*ils, elles avaient été*

Past Anterior.

I had been, etc.

j'eus été	*nous eûmes été*
tu eus été	*vous eûtes été*
il, elle eut été	*ils, elles eurent été*

Future Anterior.

I shall have been, etc.

j'aurai été	*nous aurons été*
tu auras été	*vous aurez été*
il, elle aura été	*ils, elles auront été*

Conditional.

Present.

I should be, etc.

je serais	*nous serions*
tu serais	*vous seriez*
il, elle serait	*ils, elles seraient*

Past.

I should have been, etc.

j'aurais été	*nous aurions été*
tu aurais été	*vous auriez été*
il, elle aurait été	*ils, elles auraient été*

Imperative.

Present.

sois, be (thou)
qu'il soit, qu'elle soit, let him be, let her be
soyons, let us be
soyez, be (ye)
qu'ils soient, qu'elles soient, let them be

Subjunctive.

Present.

That I may be, etc.

que je sois	*que nous soyons*
que tu sois	*que vous soyez*
qu'il, qu'elle soit	*qu'ils, qu'elles soient*

Imperfect.

That I might be, etc.

que je fusse	*que nous fussions*
que tu fusses	*que vous fussiez*
qu'il, qu'elle fût	*qu'ils, qu'elles fussent*

Past.

That I may have been, etc.

que j'aie été	*que nous ayons été*
que tu aies été	*que vous ayez été*
qu'il, qu'elle ait été	*qu'ils, qu'elles aient été*

Pluperfect.

That I might have been, etc.

que j'eusse été	*que nous eussions été*
que tu eusses été	*que vous eussiez été*
qu'il, qu'elle eût été	*qu'ils, qu'elles eussent été*

INFINITIVE.

Present.	*Past.*
être, to be	*avoir été*, to have been

PARTICIPLE.

Present.

étant, being.

Past.

été, been ; *ayant été*, having been.

REMARKS. 1. The past participle *été* is always invariable. *Être* is sometimes used impersonally instead of *y avoir*:

Il était un roi d'Yvetot, peu connu dans l'histoire, There was a king of Yvetot, little known in story.

Il était une fois un roi et une reine qui avaient un fils beau comme le jour, There were once a king and queen who had a son beautiful as the day.

2. *Être à*, followed by a noun or personal pronoun, means "to belong to."

Ce livre-ci est à moi, celui-là est à mon ami, This book belongs to me, that one belongs to my friend.

3. *Être à même de*, followed by an infinitive, means "to be able to," "to be in a position to": *Il est à même de nous aider*, He is in a position to help us.

4. *Être à*, followed by the active voice, is equivalent to the English construction in which "to be" is followed by a passive infinitive: *Il est à craindre*, He is to be feared ; *vous êtes à plaindre*, You are to be pitied.

5. *Y être* is used idiomatically, sometimes with the meaning of "to be at home," sometimes with that of "to be ready," "to understand": *J'ai besoin de parler à votre frère ; y est-il ? Non, il n'y est pas*, I want to speak to your brother ; is he at home ? No, he is not at home.

Y êtes-vous ? Oui, j'y suis, Are you ready ? Yes, I am ready.

6. The expressions *être bien avec* and *être mal avec* mean "to be on good terms with," "to be on bad terms with": *Il est bien avec tout le monde*, He is on good terms with everybody.

7. "To be," referring to the state of health, is not rendered literally by *être*, but either by the reflexive verb *se porter*, to carry oneself, or by *aller*, to go: How are you ? *Comment vous portez-vous?* or more usually *Comment allez-vous?*

8. "To be," is rendered by *valoir* in the expression "to be better (preferable)": It is better late than never, *Il vaut mieux tard que jamais*.

Ne pas Être, not to be.

INDICATIVE.

Present.	*Past Indefinite.*
je ne suis pas, etc.	*je n'ai pas été*
Imperfect.	*Pluperfect.*
je n'étais pas, etc.	*je n'avais pas été*
Past Definite.	*Past Anterior..*
je ne fus pas, etc.	*je n'eus pas été, etc.*
Future.	*Future Anterior.*
je ne serai pas, etc.	*je n'aurai pas été, etc.*

CONDITIONAL.

Present.	*Past.*
je ne serais pas, etc.	*je n'aurais pas été*

IMPERATIVE.

Present.

Ne sois pas
qu'il ne soit pas, qu'elle ne soit pas
Ne soyons pas
Ne soyez pas
qu'ils ne soient pas, qu'elles ne soient pas

SUBJUNCTIVE.

Present.	*Past.*
que je ne sois pas, etc.	*que je n'aie pas été, etc.*
Imperfect.	*Pluperfect.*
que je ne fusse pas, etc.	*que je n'eusse pas été, etc.*

INFINITIVE.

Present.	*Past.*
ne pas être	*ne pas avoir été*

PARTICIPLE.

Present.	*Past.*
n'étant pas	*n'ayant pas été*

Être, conjugated interrogatively.

INDICATIVE.

Present.	*Past Indefinite.*
suis-je ?	*ai-je été ?*
est-il, est-elle ?	*a-t-il été, a-t-elle été ?*
Imperfect.	*Pluperfect.*
étais-je ?	*avais-je été ?*
Past Definite.	*Past Anterior.*
fus-je ?	*eus-je été ?*
Future.	*Future Anterior.*
serai-je ?	*aurai-je été ?*

CONDITIONAL.

Present.	*Past.*
serais-je ?	*aurais-je été ?*

Être,

conjugated interrogatively and negatively.

INDICATIVE.

Present.	*Past Indefinite.*
ne suis-je pas ?	*n'ai-je pas été ?*
n'est-il pas ?	*n'a-t-il pas été ?*
n'est-elle pas ?	*n'a-t-elle pas été ?*
Imperfect.	*Pluperfect.*
n'étais-je pas ?	*n'avais-je pas été ?*
Past Definite.	*Past Anterior.*
ne fus-je pas ?	*n'eus-je pas été ?*
Future.	*Future Anterior.*
ne serai-je pas ?	*n'aurai-je pas été ?*
ne sera-t-il pas ?	*n'aura-t-il pas été ?*
ne sera-t-elle pas ?	*n'aura-t-elle pas été ?*

CONDITIONAL.

Present.	*Past.*
ne serais-je pas ?	*n'aurai-je pas été ?*

In English, a positive statement followed by the negative-interrogative form of "have," "be," or one of the modal auxiliaries "do," "can," "ought," "should," etc., is used to indicate that the answer "Yes" is expected. In French, the one expression *N'est-ce pas ?* is used, whatever be the auxiliary, the tense, or the person:

He is a friend of yours, is he not ? *C'est un de vos amis, n'est-ce pas ?*

You speak French, do you not ? *Vous parlez français, n'est-ce pas ?*

He wrote to you last week, did he not ? *Il vous a écrit la semaine dernière, n'est-ce pas ?*

They will be there, will they not ? *Ils y seront, n'est-ce pas ?*

EXERCISE XXII.

1. Whose books are those ? They are my brother's.
2. I wanted to speak to your father, but he was not in.
3. The ass is temperate (*sobre*) and patient ; it would be the handsomest of domestic animals if there were no horse.
4. The Gauls (*Gaulois*) were brave and strong (*robuste*).
5. Marshal Lannes had been (a) dyer ; Marshal Ney was a cooper before being (to be) (a) soldier.
6. The father of the philosopher (*philosophe*) Diderot, and that of the historian (*historien*) Rollin were cutlers (*couteliers*).
7. Pardon is better than revenge (*la vengeance*).
8. The Romans (*Romains*) were the masters of the world (*le monde*).
9. There were once two men who were very poor and very wretched (*malheureux*).
10. The first was blind (*aveugle*) from his birth (*de naissance*) ; the second was paralysed.
11. They were both incapable of doing (*faire*) anything.
12. The blind (man), who was strong, carried (*porta*) the paralytic (*paralytique*).
13. The paralytic, who was endowed (*doué*) with (a) good sight (*la vue*), guided (*dirigea*) his companion.
14. Alone they would have (*être*) died (*morts*) of hunger.
15. United (*unis*) they were able to gain their living (*vie*).

Regular Verbs

1. There are four conjugations, distinguished from each other by the ending of the infinitive.
2. The infinitive of the first conjugation ends in *er*, as *donner*, to give.
3. The infinitive of the second conjugation ends in *ir*, as *finir*, to finish.
4. The infinitive of the third conjugation ends in *oir*, as *recevoir*, to receive.
5. The infinitive of the fourth conjugation ends in *re*, as *vendre*, to sell.
6. Regular verbs are those of which all the tenses are formed uniformly from the primitive tenses, or principal parts.
7. The primitive tenses, or principal parts, are five: (*a*) *the present of the infinitive*, (*b*) *the present participle*, (*c*) *the past participle*, (*d*) *the present indicative*, and (*e*) *the past definite*.
8. For each of the conjugations the principal parts are as follow:

FIRST CONJUGATION: *donner, donnant, donné, je donne, je donnai.*

SECOND CONJUGATION: *finir, finissant, fini, je finis, je finis.*

THIRD CONJUGATION: *recevoir, recevant, reçu, je reçois, je reçus.*

FOURTH CONJUGATION: *vendre, vendant, vendu, je vends, je vendis.*

I. From the *present of the infinitive* are formed: (*a*) the *future indicative*, and (*b*) the *present conditional* by changing *r* of the first and of the second conjugation, *oir* of the third conjugation, and *re* of the fourth conjugation into *rai, ras, ra, rons, rez, ront* for the *future*, and into *rais, rais, rait, rions, riez, raient* for the *conditional*:

DONNE-R	FINI-R
Future.	*Future.*
je donne-rai	*je fini-rai*
tu donne-ras	*tu fini-ras*
il donne-ra	*il fini-ra*
nous donne-rons	*nous fini-rons*
vous donne-rez	*vous fini-rez*
ils donne-ront	*ils fini-ront*
Conditional	*Conditional*
je donne-rais	*je fini-rais*
tu donne-rais	*tu fini-rais*
il donne-rait	*il fini-rait*
nous donne-rions	*nous fini-rions*
vous donne-riez	*vous fini-riez*
ils donne-raient	*ils fini-raient*

RECEV-OIR.	VEND-RE.
Future.	*Future.*
je recev-rai	*je vend-rai*
tu recev-ras	*tu vend-ras*
il recev-ra	*il vend-ra*
nous recev-rons	*nous vend-rons*
vous recev-rez	*vous vend-rez*
ils recev-ront	*ils vend-ront*
Conditional	*Conditional.*
je recev-rais	*je vend-rais*
tu recev-rais	*tu vend-rais*
il recev-rait	*il vend-rait*
nous recev-rions	*nous vend-rions*
vous recev-riez	*vous vend-riez*
ils recev-raient	*ils vend-raient*

EXCEPTIONS: 1. First Conjugation—*Aller*, to go ; future, *j'irai* ; conditional, *j'irais.*

Envoyer, to send ; future, *j'enverrai* ; conditional, *j'enverrais.*

2. Second Conjugation: *Acquérir*, to acquire ; future, *j'acquerrai* ; conditional, *j'acquerrais.*

Courir, to run ; future, *je courrai* ; conditional, *je courrais.*

Cueillir, to gather ; future, *je cueillerai* ; conditional, *je cueillerais.*

Mourir, to die ; future, *je mourrai* ; conditional, *je mourrais.*

Tenir, to hold ; future, *je tiendrai* ; conditional, *je tiendrais.*

Venir, to come ; future, *je viendrai* ; conditional, *je viendrais.*

3. Third Conjugation: *Asseoir*, to seat ; future, *j'assiérai* ; conditional, *j'assiérais.*

Avoir, to have; future, *j'aurai*; conditional, *j'aurais.*

Falloir, to be necessary; future, *il faudra*; conditional, *il faudrait.*

Savoir, to know; future, *je saurai*; conditional, *je saurais.*

Valoir, to be worth; future, *je vaudrai*; conditional, *je vaudrais.*

Voir, to see; future, *je verrai*; conditional, *je verrais.*

Vouloir, to wish; future, *je voudrai*; conditional, *je voudrais.*

4. Fourth conjugation: *Être*, to be; future, *je serai*; conditional, *je serais.*

Faire, to make; future, *je ferai*; conditional, *je ferais.*

II. From the PRESENT PARTICIPLE are formed (*a*) the three persons plural of the *Present Indicative*, by changing *ant* into *ons, ez, ent*; but the third person plural of the third conjugation has the further change of *e* into *oi* in the penultimate syllable:

DONN-ANT	FINISS-ANT
nous donn-ons	*nous finiss-ons*
vous donn-ez	*vous finiss-ez*
ils donn-ent	*ils finiss-ent*
RECEV-ANT	**REND-ANT**
nous recev-ons	*nous rend-ons*
vous recev-ez	*vous rend-ez*
ils (reçoiv-ent)	*ils rend-ent.*

Exceptions:

1. First Conjugation: *Allant*, going; *ils vont.*

2. Third Conjugation: *Ayant*, having; *nous avons, vous avez, ils ont.*

Sachant, knowing; *nous savons, vous savez, ils savent.*

3. Fourth Conjugation: *Étant*, being; *nous sommes, vous êtes, ils sont.*

Disant, saying; *vous dites.*

Faisant, making; *vous faites, ils font.*

(*b*) The IMPERFECT OF THE INDICATIVE, by changing *ant* into *ais, ais, ait, ions, iez, aient.*

DONN-ANT	FINISS-ANT
je donn-ais	*je finiss-ais*
tu donn-ais	*tu finiss-ais*
il donn-ait	*il finiss-ait*
nous donn-ions	*nous finiss-ion*
vous donn-iez	*vous finiss-iez*
ils donn-aient	*ils finiss-aient*
RECEV-ANT	**VEND-ANT**
je recev-ais	*je vend-ais*
tu recev-ais	*tu vend-ais*
il recev-ait	*il vend-ait*
nous recev-ions	*nous vend-ions*
vous recev-iez	*vous vend-iez*
ils recev-aient	*ils vend-aient*

Exceptions:

Third Conjugation: *Ayant*, having; *j'avais*, etc.; *sachant*, knowing; *je savais*, etc.

(*c*) The PRESENT SUBJUNCTIVE by changing *ant* into *e, es, e, ions, iez, ent;* but, in the third conjugation the three persons of the singular, and the third person plural require the further change of the *e* of the penultimate syllable into *oi*. The preceding *c* then takes a cedilla.

DONN-ANT.	FINISS-ANT
que je donn-e	*que je finiss-e*
que tu donn-es	*que tu finiss-es*
qu'il donn-e	*qu'il finiss-e*
que nous donn-ions	*que nous finiss-ions*
que vous donn-iez	*que vous finiss-iez*
qu'ils donn-ent	*qu'ils finiss-ent*
RECEV-ANT	**VEND-ANT**
que je (reçoiv-e)	*que je vend-e*
que tu (reçoiv-es)	*que tu vend-es*
qu'il (reçoiv-e)	*qu'il vend-e*
que nous recev-ions	*que nous vend-ions*
que vous recev-iez	*que vous vend-iez*
qu'ils (reçoiv-ent)	*qu'ils vend-ent*

Exceptions:

1. First Conjugation: *Allant*, going; *que j'aille, que tu ailles, qu'il aille, qu'ils aillent.*

2. Second Conjugation: *acquérant*, acquiring; *que j'acquière, que tu acquières, qu'il acquière, qu'ils acquièrent.*

Mourant, dying; *que je meure, que tu meures, qu'il meure, qu'ils meurent.*

Tenant, holding; *que je tienne, que tu tiennes, qu'il tienne, qu'ils tiennent.*

Venant, coming; *que je vienne, que tu viennes, qu'il vienne, qu'ils viennent.*

3. Third Conjugation: *Fallant* (not used), it being necessary; *qu'il faille.*

Mouvant, moving; *que je meuve, que tu meuves, qu'il meuve, qu'ils meuvent.*

Pouvant, being able; *que je puisse, que tu puisses, qu'il puisse, que nous puissions, que vous puissiez, qu'ils puissent.*

Valant, being worth; *que je vaille, que tu vailles, qu'il vaille, qu'ils vaillent.*

Voulant, wishing; *que je veuille, que tu veuilles, qu'il veuille, qu'ils veuillent.*

4. Fourth Conjugation: *Étant*, being; *que je sois, que tu sois, qu'il soit, que nous soyons, que vous soyez, qu'ils soient.*

Buvant, drinking; *que je boive, que tu boives, qu'il boive, qu'ils boivent.*

Faisant, making; *que je fasse, que tu fasses, qu'il fasse, que nous fassions, que vous fassiez, qu'ils fassent.*

Only three verbs—*être* (to be), *pouvoir* (to be able), and *faire*, (to make) are irregular throughout the whole of the present subjunctive: *que je sois, que je puisse*, etc; *que je fasse*, etc. In none besides these are the first and second persons plural irregular.

KEY TO EXERCISE XXI.

1. Ils avaient peur de nous, mais ils auront encore plus peur de vous.
2. N'ont-ils pas honte de leur conduite ?
3. Nous aurions raison, et vous auriez tort.
4. Nous avons eu bien froid.
5. N'y avait-il pas quelqu'un dans la maison ?
6. Quel âge cet enfant a-t-il ?
7. Il aura douze ans le mois prochain.

8. Il a un peu plus de deux ans de plus que sa sœur.

9. Avez-vous bien faim. Non, merci, mais j'ai bien soif.

10. S'il n'y avait pas de feu, nous aurions bien froid.

11. Je n'ai jamais eu plus froid aux mains.

12. N'aurez-vous pas trop chaud si près du feu ?

13. J'ai eu seize ans il y a quinze jours.

14. Qu'avaient ces enfants ? Ils avaient peur de ce gros chien.

15. Ils auraient eu moins peur du chat que du chien.

16. Quand a eu lieu la première représentation de cette comédie ?

17. Elle a eu lieu il y a un peu plus de six mois.

18. Si vous avez besoin d'un dictionnaire, prenez le mien, mais ayez en bien soin.

19. Il y a dix minutes que nous vous attendons.

20. Vous aurez beau dire ; on ne vous croira pas.

Continued

GERMAN

Continued from page 2778

By P. G. Konody and Dr. Osten

XLIX. Use of Auxiliary Verbs of Tense. The auxiliary verb werden, to become, to grow, is employed with *all* verbs for the formation of the first and second future, of the two conditionals in the active voice, and of *all* tenses in the passive voice. The *infinitive past*, the *perfect* and *pluperfect* of all verbs are formed with the aid of either (*a*) sein, to be, or (*b*) haben, to have. Certain verbs form these compound tenses (*c*) alternately with sein or haben.

(*a*) The majority of verbs are conjugated with haben—especially the *transitive, reflective*, and *impersonal* verbs denoting actions and lasting effects of actions, and some *intransitive* verbs.

(*b*) With sein are conjugated many *intransitive* verbs, especially those denoting change of locality, motion and transition into other states. To this class naturally belong the verbs with the prefixes indicating motion—her-, hin-, herab-, hinauf-, etc.

(*c*) Some transitive and intransitive verbs admit the use of both sein and haben, according to the state of action, motion, etc., which is to be expressed. Examples: ich bin geeilt, and ich habe geeilt, I have hurried; or: ich bin geritten and ich habe geritten, I have ridden, etc. In these cases haben is used where the action of the subject is a more accentuated, settled process of activity; whilst sein indicates transitions from one state into another. With sein are conjugated: begeg'nen, to meet; folgen, to follow; liegen, to lie, lay; sitzen, to sit; stehen, to stand; weichen, to yield, to give way; glücken, gelin'gen, to succeed; misglücken, misraten, mislingen, to fail; and gehen, to go, to walk. Thus gehen is conjugated with sein: ich bin gegangen (literally: I am gone); but in the reflective form: ich habe mich müde gegangen, I have walked myself tired (I have tired myself out with walking). Frequently the *general*, unspecified character of the action is denoted by the use of haben, and the special one by the use of sein. Thus to express in a *general* way that one has been on horseback, one would say: ich bin geritten, (literally: I am ridden); but ich habe das Pferd geritten, (I have ridden the horse; or ich bin zur Mühle geritten (literally: I am ridden to the mill), but ich habe das Pferd zur Mühle geritten (I have ridden the horse to the mill).

1. Several *intransitive* verbs, like the following, are conjugated with haben: zu'nehmen, to increase; ab'nehmen, to decrease; an'fangen, begin'nen, to begin; auf'hören, to cease; blühen, to blossom; brennen, to burn; bellen, to bark; fechten, to fight; glühen, to glow; lachen, to laugh; leuchten, to light; nach'lassen, to leave off; ruhen, to rest; scheinen, to shine; schlafen, to sleep; wachen, to watch; weinen, to weep, cry. etc. Ich habe die Arbeit angefangen, I have begun the work; and *intransitive*: die Arbeit hat angefangen, the work has begun; and in the *passive* of the transitive: die Arbeit ist angefangen, the work is begun.

2. The following verbs are conjugated either with sein or haben: eilen, to hasten; fahren, to drive; hängen, to hang; knieen, to kneel; kriechen, to creep; laufen, to run; liegen, to lie (in the physical sense); reiten, to ride; schweben, to be suspended; schwimmen, to swim; sitzen, to sit; springen, to jump; stehen, to stand; stolpern, to stumble; treten, to tread; wandern, to wander. Examples: ich bin or ich habe gekniet (I have knelt); ich bin or ich habe geschwommen (I have swum), etc.

L. Interjections. As in English, the interjections denote joy, sorrow, surprise, fear, horror, etc., or call attention to something. Those chiefly in use are: O! Ah! Ha! Ach! (for surprise); O weh! Au! (for pain); Brrr! (to express coldness and shuddering); Aha! (used like "I see," to express understanding); I! Ei! or Ei Ei! Hm Hm! (for wonder or surprise); Pfui! (fie! for shame!); Heda! Hallah! He! Pst! (for calling attention, like the English "I say!"); and several imitative sounds like Plumps! Husch! Piff Paff Puff! (to mark a sudden disappearance or a sudden fall into water, mostly used in fairy tales and nursery tales, also the firing of guns). These latter and similar interjections, like Rumweidibum! Schnedderengteng! (in imitation of drums and brass instruments) are used in a semi-humorous way in descriptions of folklore character. Hoch! Hurrah! Heil! are interjections for cheering; Prost! (or Prosit!)

for drinking. Zeter und Mor'dio! Bomben und Grana'ten! Himmel und Hölle! are exclamations of anger and force, akin to swearing. The military command of Fire! Feuer! as well as the fire-call, Feu'rio! are counted among the interjections. The interjections are often combined with the fifth case, the vocative, which is treated in the next paragraph.

LI. The Vocative Case. This, the fifth case in the declension of nouns, is the mode of address, and is thus employed only with persons, with personal pronouns in the second person, and with nouns personified: Du (vocative) schreibe! Thou write! (imperative). Ihr (vocative) gehet! You go! Meine .... My ancestors! Du, mein lieber Vater! Thou, my dear father! Du tapferes Schwert! Thou brave sword!

The vocative is also used with interjections: O Gott! O Himmel! (Oh God! Oh Heaven!), Ach Herr Jesus! (Oh, Lord Jesus!) etc. It also serves for the mode of address in letters: Geehrter Herr! [Honoured] Dear sir. Bester Freund! [Best] Dear friend. The vocative has traits similar to the imperative and the interjection, and is often employed with them. As regards inflection, the vocative is identical with the nominative.

LII. The following strong verbs with the stem-vowel -a- change it in the imperfect into -i-, -ie-, or -u-, but retain the original stem-vowel in the past participle.

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
blasen	to blow	ich blase, bläsest, bläst	ich blies	ich bliese	blas(e)	geblasen
braten	to roast	„ brate, brätst, brät (bratest, bratet)	„ briet	„ briete	brat(e)	gebraten
empfangen	to receive	„ empfange, empfängst, empfängt	„ empfing	„ empfinge	empfang(e)	empfangen
fallen	to fall	„ falle, fällst, fällt	„ fiel	„ fiele	fall(e)	gefallen
fangen	to catch	„ fange, fängst, fängt	„ fing	„ finge	fang(e)	gefangen
gefallen	to please	„ gefalle, gefällst, gefällt	„ gefiel	„ gefiele	gefall(e)	gefallen
geraten	to come upon	„ gerate, gerätst, gerät	„ geriet	„ geriete	gerat(e)	geraten
halten	to hold	„ halte, hältst, hält	„ hielt	„ hielte	halt(e)	gehalten
hangen *	to hang	„ hange, hängst, hängt	„ hing	„ hinge	hang(e)	gehangen
lassen	to let	„ lasse, lässest, läßt	„ ließ	„ ließe	laß	gelassen
mißfallen	to displease	„ mißfalle, -fällst, -fällt	„ mißfiel	„ mißfiele	mißfall(e)	mißfallen
raten	to advise	„ rate, rätst, rät	„ riet	„ riete	rat(e)	geraten
schlafen	to sleep	„ schlafe, schläfst, schläft	„ schlief	„ schliefe	schlaf(e)	geschlafen
backen	to bake	„ backe, bäckst, bäckt	„ buk (backte)	„ büke (backte)	back(e)	gebacken
fahren	to drive	„ fahre, fährst, fährt	„ fuhr	„ führe	fahr(e)	gefahren
graben	to dig	„ grabe, gräbst, gräbt	„ grub	„ grübe	grab(e)	gegraben
laden	to summon, charge, load	„ { lad-e, -est, -et or lade, lädst, lädt }	„ lud	„ lüde	lad(e)	geladen
schaffen †	to procure, provide	„ schaff-e, -st, -t	„ schuf	„ schüfe	schaff(e)	geschaffen
schlagen	to strike	„ schlage, schlägst, schlägt	„ schlug	„ schlüge	schlag(e)	geschlagen
tragen	to carry	„ trage, trägst, trägt	„ trug	„ trüge	trag(e)	getragen
wachsen	to grow	„ wachse, wächst, wächst	„ wuchs	„ wüchse	wachs(e)	gewachsen
waschen	to wash	„ wasche, wäschest, wäscht	„ wusch	„ wüsche	wasch(e)	gewaschen

* As intransitive (without complement), ***strong;*** as transitive, ***weak***, hängen (aufhängen); imperative: hängte; past participle: gehängt.

† In the sense of "to work" ***weak:*** Hier wird nichts geschafft (gearbeitet). Here is nothing done.

LIII. The following strong verbs with the stem-vowel -e-, -u-, -au-, or -ei- change it in the imperfect into -ie-, but retain the original stem-vowel in the past participle.

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
stoßen	to push	ich stoße, stößt, stößt	ich stieß	ich stieße	stoß(e)	gestoßen
rufen	to call	„ ruf-e, -st, -t	„ rief	„ riefe	ruf(e)	gerufen
laufen	to run	„ laufe, läufst, läuft	„ lief	„ liefe	lauf(e)	gelaufen
heißen	to name	„ heiße, heißest, heißt	„ hieß	„ hieße	heiß(e)	geheißen
hauen	to hew	„ hau-e, -st, -t	„ hieb	„ hiebe	hau(e)	gehauen

LIV. Irregular changes of the stem-vowels are to be noted in the following verbs:

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
erschal'len	to resound	er, sie, es erschallt	erscholl	erschölle	erschall(e)	erschollen
schwören	to swear	ich schwöre, -st, -t	ich schwor, also schwur	ich schwöre (schwüre)	schwör(e)	geschworen
verlö'schen *	to be extinguished, go out	„ verlösche, verlöschest, verlöscht.	ich verlosch	„ verlösche	verlösch(e)	verloschen
stehen	to stand	„ steh-e, -st, -t	ich stand, also stund	„ stände (stünde)	steh(e)	gestanden
kommen	to come	„ komm e, -st, -t	ich kam	„ käme	komm	gekommen
lügen	to lie	„ lüg-e, -st, -t	„ log	„ löge	lüg(e)	gelogen
tun	to do	„ tu-e, -st, -t; wir tun (subj. ich tu-e, -est)	„ tat	„ täte	tu(e)	getan
schinden	to flay, skin	„ schind-e, -est, -et	„ schund	„ schünde	schind(e)	geschunden

* The transitive compound of löschen: auslöschen is weak: Er hat das Feuer ausgelöscht, He has extinguished the fire.

EXAMINATION PAPER XIV.

1. For the formation of which tenses is the auxiliary verb werden used?
2. With which auxiliary verb of tense are the majority of verbs conjugated, and to which groups of verbs does this rule most particularly apply?
3. How does the character of a verb (its being transitive or intransitive, reflective or impersonal) determine the use of sein or haben in the formation of compound tenses?
4. With which verb is the auxiliary verb sein employed?
5. In what state of action is the auxiliary verb haben used for the formation of the compound tenses?
6. What circumstances determine the use of sein or haben in the compound tenses of the verb reiten, to ride (on horseback)?
7. What is the characteristic feature in the formation of the past participle of many strong verbs that change the stem-vowel -a- into -ie- or -u- in the imperfect?
8. Which vowel is taken in the imperfect by verbs with the stem-vowel -o-, -u-, -au-, and -ei- in the infinitive and past participle?

Exercise. Transpose the following tenses from the past and pluperfect to the imperfect.

Ich habe die Trompete geblasen; du hattest
I have blown the trumpet; you had re-
ihn empfangen; die Feinde haben den Offizier gefangen;
ceived him; the enemies have captured the officer;
sie hat mir gefallen; das Kind ist gewachsen;
she has pleased me; the child has grown;
die Frauen hatten die Wäsche gewaschen;
the women had washed the washing;
wer hat mich gerufen? Du bist schnell gelaufen;
who has called me? You have run quickly;
er hat mich gestoßen; wann seid ihr gekommen?
he has pushed me; when did you come? (have you come?)
Der Bursche hat gelogen; er hatte einen Eid geschworen.
The lad has lied; he had sworn an oath.
Was haben Sie getan? Ich habe es getragen.
What have you done? I have carried it.
Wir waren eben nach Hause gekommen;
We had just come home;
ich habe meine Pflicht getan.
I have done my duty.

Key to Exercise 3, Page 2640

Nachdem die Damen sich zurückgezogen hatten, rauchten wir; weil Niemand uns die Tür öffnete, gingen wir fort; ehe ich ihm ein Wort sagen konnte, verschwand er; wenn es genügend viel regnet, wächst der Weizen; ob ich zürne, frug er mich; falls das Wetter es zuließe, wünschte er abzureisen; als er kam, schlief ich; da man sie bat, es zu tun, sang sie ein Lied; solange Sie es mir nicht zugesagt haben, gehe ich nicht fort.

Keys to Exercises in Examination Paper XIII. Page 2778

Exercise 1. Ich kenne einen Mann, der verheiratet ist; ich sprach mit der Frau, deren Mann krank ist; dies sind die Kinder, welche wir gestern im Walde trafen. Kennen Sie die Mädchen, deren Brüder Tennis spielen? Ich begeg'nete der Frau, deren Mann beim Schiffbruch um'kam; dies ist der Knabe, der mich durch den Wald führte. Er ist ein Mann, dessen Güte allgemein bekannt ist.

Exercise 2 (a). Der Soldat ficht tapfer; der Wind bewegt die Zweige der Bäume; der Sonnen-un'tergang bewegt mich umzukehren; das Mädchen flicht einen Kranz; er hebt das Faß; die Schäfer scheren die Schafe; die Knaben fliehen; das Wasser fließt rasch.

(*b*) *Imperfect:* Sie genossen nicht, etc.; die Schlange kroch, etc.; das Wasser sott; der Jäger schoß vorzüglich; ich verlor mein Geld; ich verbot, etc.; die Blumen rochen gut; ich glaube der Mann betrog mich; die Pflanze sog, etc.

Perfect: Sie haben nicht die Schönheit der Landschaft genossen; die Schlange ist über den Weg gekrochen; das Wasser hat gesotten; der Jäger hat vorzüglich geschossen; ich habe mein Geld verloren; ich habe Ihnen dies ernstlich verboten; die Blumen haben gut gerochen; ich glaube der Mann hat mich betrogen; die Pflanze hat ihre Nahrung aus dem Boden gesogen (or gesaugt).

Exercise 3. Er ist nicht jedermanns Freund. Wo man geboren ist, dort heimelt es einen an; es ist nicht jedermanns Geschmack zu streiten; haben Sie etwas gehört? Nein, ich habe nichts gehört; ich glaube niemand(em), den ich nicht kenne. Jemandes Hand muß dabei im Spiele gewesen sein.

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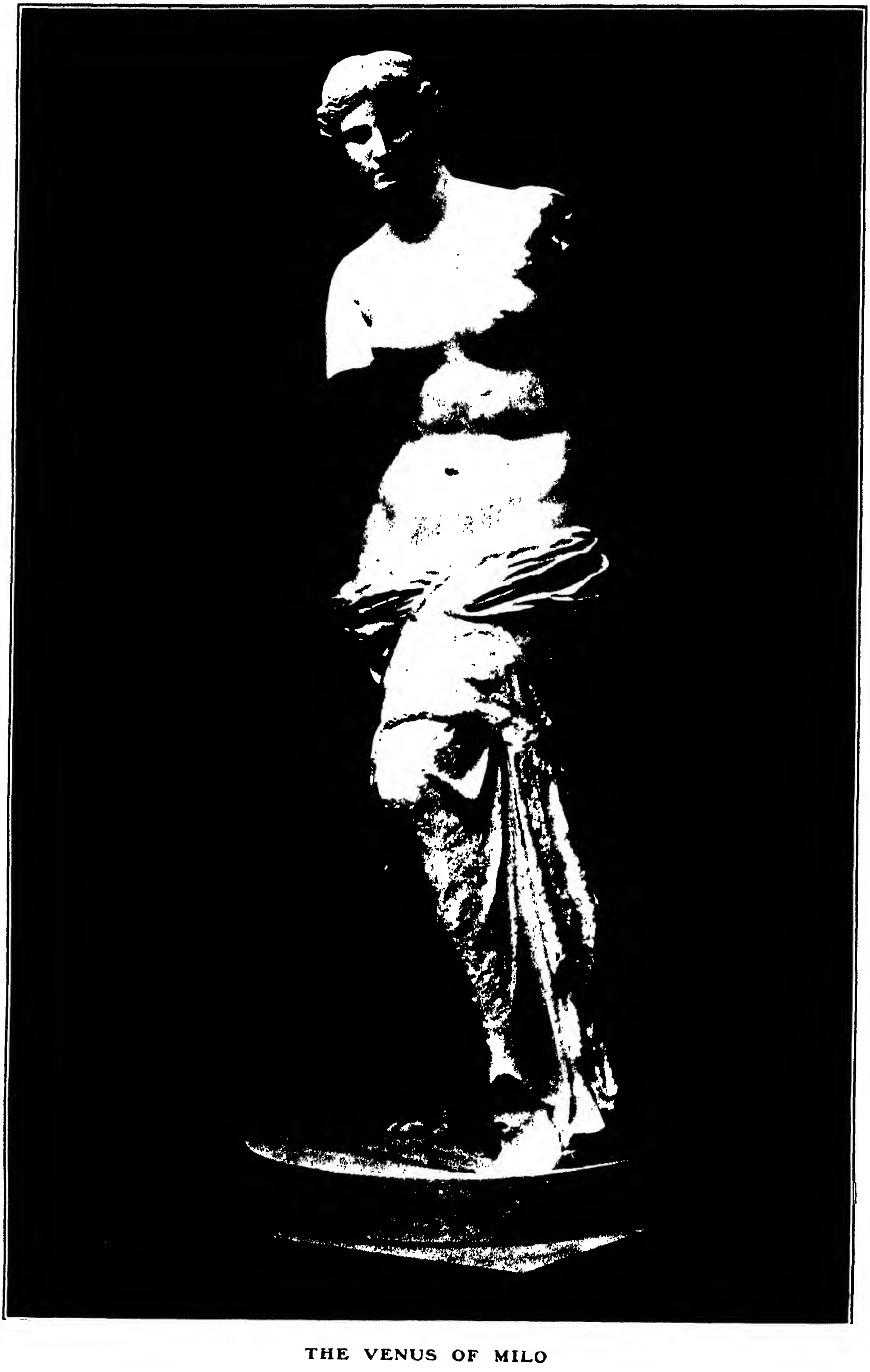


THE VENUS OF MILO

GREEK AND ROMAN SCULPTURE

The Greek Ideal. Famous Grecian Sculptors. Roman Art: Sculpture, Architecture, Relief Carving, and Painting

continued from page 2853

By P. G. KONODY

Beginnings of Greek Sculpture. Greek genius found its most perfect expression in sculpture, which, in the course of barely two centuries (from about 620 B.C. till the middle of the fifth century) advanced with astounding rapidity from barbaric archaism to a perfection of harmony and beauty which has set the standard, the "classic" ideal for all ages to come, has never since been surpassed, and but rarely approached. The Greek achievement was the result of the perfect balance of mind and body, of political freedom, and of a natural instinct for beauty which was constantly fed by the sight of graceful and lithe movement, of beautifully developed bodies, draped or nude, engaged in dance or physical exercise. The ancient Greek was a worshipper of the perfect human body, and conceived his gods and goddesses in human form, in which respect he differed essentially from the Egyptian and Assyrian.

In humanising his gods in this fashion, it was only natural that the Greek sculptor should have endeavoured to eliminate the accidental and personal, in order to create a perfect, impersonal type, serene and unemotional. And having found the proportions of features which most pleased his artistic sense, he was satisfied with indicating such marked differences as between youth and ripe age, male and female, without attempting individualised expression.

The earliest Greek works of plastic art—"Greek," as differing from Minoan and Mycenæan—point clearly to Egyptian and Assyrian influences, though even in these archaic works there is an undeniable striving after truth, a searching for form even under the draperies. The first great step towards freedom was made by a Chian sculptor, Achermos, who is the author of a statue of a running Nike, which has been found at Delos—a work which is still archaic in character, but marks an immense advance from the earlier stiffness.

The Master Sculptors of Greece. The great period of Greek sculpture begins with the Argive school, with Agelaides, about 560 B.C., the teacher of the three great masters Pheidias, Polycleitus, and Myron. The famous "Doryphorus" of Polycleitus was in classic times already set up as the ideal of human proportion, and was one of the earliest statues in which the weight of the body, instead of resting on both feet, is thrown on to one foot, whilst the other leg is "free-standing," with the heel raised from the ground, a device which results in a wonderful ease of attitude and sets certain muscles into play.

Myron was one of the first to discard the rigid uprightness of chest and head, and to show the full flexibility of the body in action. His statues of athletes, among them the famous Discus Thrower, a copy of which is preserved in a Roman collection, are notable instances of his art. With Pheidias the school reached its apogee, but although this master's greatness has been proclaimed by his contemporaries and by historians of all times, there is not a single work which can be definitely pronounced to have been wrought by his hand. It is very likely that the sculptures of the Parthenon were either his own, or made under his personal direction; and M. Reinach holds the opinion that the world-famed Venus of Milo belongs to the school of Pheidias [see frontispiece]. Pheidias was the leading spirit in the sculptural decoration of the Acropolis, and was responsible for the execution of the colossal statue of Athene, by which this wondrous group of buildings was dominated, a statue about 40 ft. in height, wrought of gold and ivory on a wooden kernel. Pheidias was, above all, the sculptor of the Olympian gods, and whilst his work embodied the highest development of Greek art in rendering physical beauty, the beauty of form, he achieved what his precursors and contemporaries had never arrived at, perhaps never tried for—the expression of spiritual dignity and exaltation.

Expression of Human Emotion. In the third period of Greek sculpture, which embraces the fourth century down to the time of Alexander the Great, the former ideal of merely physical life and spiritual serenity is abandoned for the expression of human passions and emotions. The three great masters of this period are Scopas, Praxiteles, and Lysippus. The pathos and emotion which were at the command of Scopas's chisel appear in a work like the famous Niobe group, which is presumably his. The wonderful Nike of Samothrace is yet another of the world's masterpieces that betrays at least his influence. There is less passion and more dreamy tenderness, with an appropriate soft rendering of the forms in such works of Praxiteles as have come down to us, the most famous and characteristic of which are probably the Venus of Cnidus, at the Vatican, and the Hermes of the Olympia Museum. Lysippus, who is said to have produced no less than 1,500 works, mostly in bronze, delighted most in representations of physical vigour, and therefore chose Hercules as his favourite theme. He also excelled in portraiture, and produced many statues of Alexander the Great, who refused to give "sittings" to any other sculptor. The work by which Lysippus is best known to us is the superb Apoxyomenus of the Vatican Museum [page 184].

With the death of Alexander the Great, and the formation of independent states by his

generals, Athens ceased to be the centre of Greek art, and new schools arose in the capitals of the different despots, notably at Pergamum, Alexandria, and Antioch. Art was no longer the glory of a free people, but had entered the service of princes. It is quite natural that the new conditions should be reflected in the art productions which now, in the "Hellenistic" period, made more for outward show and effect than for the pure ideal of the Hellenic or Attic period. Yet the Hellenistic period can scarcely be called a period of decline, for it had so much artistic vitality that it extended the realm of art to regions that had never before been approached. "After serene strength (Phidias), languorous grace (Praxiteles), passion (Scopas), and nervous elegance (Lysippus), art had yet to express physical suffering, anguish, the tumult and disorder of the soul and the body, and this was admirably done by the schools of Rhodes and Pergamum." (S. Reinach.)

The Hellenistic Period. The great Laocoon group, by three Rhodian sculptors, Agesandros, Athenodoros, and Polydoros, is the most famous and characteristic work of the Hellenistic period, and physical suffering has never perhaps found better expression than in the writhing, struggling figures of the priest of Apollo and his two sons [30]. The great Farnese Bull, of the Naples Museum, belongs to the same period, and follows the same art ideal. The most extensive and important work of the Pergamenian period is the frieze—some 300 ft. in length—of the Zeus altar erected by Eumenes II., about 200 B.C., which is now the glory of the Berlin Museum. Here again the keynote that runs through the entire work is violent movement and fierce struggle. Wonderful, too, is the realism of the "Dying Gaul," at the Capitoline Museum in Rome, one of the most famous works of the Pergamese school [32]. Human passions and emotions are expressed even in the statues of the Olympian gods of the Hellenistic period, such as the Belvedere Apollo, whose face is full of fire and excitement as his eyes follow the dart he has hurled at the python [31].

30. THE LAOCOON GROUP *Anderson*
The Vatican Museum, Rome

As in sculpture, so in the arts of cutting cameos and striking coins, the Greeks of the classic period attained to a level of perfection that has never since been equalled. The absence of positive evidence makes our knowledge of Greek painting very fragmentary. There is no lack of literary records and anecdotes, such as the amusing stories told about Zeuxis and Parrhasios, and about the deceptive realism of their paintings. But there is no measure of comparison with modern achievement, and what may have appeared marvellously plastic and realistic to the ancients may strike the modern eye as flat and unreal. Positive evidence is only to be found in the necessarily conventional vase-painting, and in the Pompeian wall decorations, executed by Greek artists in a period of decline — paintings which reflect probably but a shadow of the Greek achievement of the Attic, the Ephesian, and the Sikyon schools.

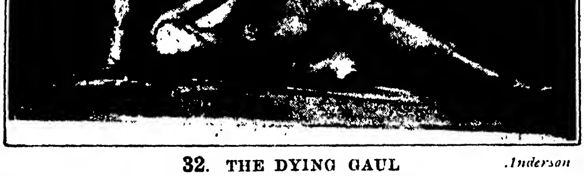
We can form an idea of the pictorial fancy, the rhythm of line, the skilful arrangement, the exquisite draughtsmanship, the knowledge of light and shade, the harmony of colour, of Greek painting, but we do not know whether Grecian art ever got beyond mere local colouring. As regards subject, the Greeks had almost as wide a range as the moderns: it comprised history, mythology, scenes of actual life, caricature, still life, and portraiture. They used the fresco technique for wall paintings, and tempera for panels. In the best period they used the encaustic method, painting with dry wax-sticks, and burning the colours into the carefully-prepared surface. Many names of Greek painters have come down to us, though of their works not a trace is left.

First Attempts at Perspective. The decorative paintings of Polygnotos and Mikon were coloured outline drawings without modelling,

shadow, or perspective. Agatharchos, at the end of the fifth century B.C., was one of the first artists who devoted his attention to perspective, whilst Apollodoros was a master of light and shade and modelling. All these belonged to the Ionic school. In Ephesus, Zeuxis and Parrhasios mark the step towards realism. It is said that the former painted a bunch of grapes so true to nature that birds tried to pick at the fruit, whereupon his rival painted a curtain so deceptive that Zeuxis asked him to pull it aside. Greek painting reached its apogee in Apelles, in the second half of the fourth century, after which begins the period of decline, of waning idealism, and striving for extreme naturalism. It was then that the art of mosaic painting was developed which was to become so popular in the decoration of Roman houses.

31. APOLLO BELVEDERE *Anderson*
The Vatican Museum, Rome

Roman Art. The art of Rome is partly a development of Etruscan art, partly an importation from Greece. Long before the conquest of Etruria, the Etruscans, whose ethnological origin is still shrouded in mystery, had a characteristic civilisation and art of their own, and excelled in the crafts of the potter, the jeweller, the bronze-caster, and the stone-carver. But their art, though in time it was permeated by Greek influences, lacked the pure beauty and serenity of Greek art, as well as its idealism. Numerous paintings have been found on the walls of subterranean Etruscan tombs—coloured outline drawings of figures, dancing, or hunting, or feasting, without any attempt at pictorial composition, but rather in the manner of reliefs. The so-called "Etruscan" vase-paintings are now proved to have been produced by Greek craftsmen, but the numerous terra-cotta figures and portraits are the products of a vigorous indigenous art.



32. THE DYING GAUL *Anderson*
The Capitoline Museum, Rome

Roman Architecture. In architecture the Etruscans introduced for the first time in Europe the arch, formed of wedge-shaped stones, to replace the natural form of the horizontal architrave. The discovery of the full possibility of the arch was, however, left to the Romans, in whose hands the entire art of architecture was reformed by the introduction of the arch as a structural system. The knowledge of the strength and power of resistance of the arch led first to its use for the semicircular or waggon headed vault, then to the cross vault, and finally to the dome or cupola. It practically removed all former restrictions, and gave the builders a freedom of invention and chances for novel combinations of architectural motifs that had never been thought of before. The Coliseum, the Pantheon, and the Arch of Titus in Rome, may be mentioned as the three best known examples of Roman arched and vaulted buildings [34].

The arch, in spite of its great possibilities of decorative use, was an eminently practical device, quite in keeping with the sober, reasonable, practical spirit of the ancient Romans, a race of conquerors who cultivated art more in the spirit of the collector than of the producer. They were great in appreciation, but not in creation, of paintings and statuary, which they imported in enormous quantities from the conquered Greek states and colonies, besides giving constant employment to skilled Hellenic artists and craftsmen. Only in architecture have they left an important legacy to the world [35], and even in this sphere they had to fall back on the Greek architectural system to introduce

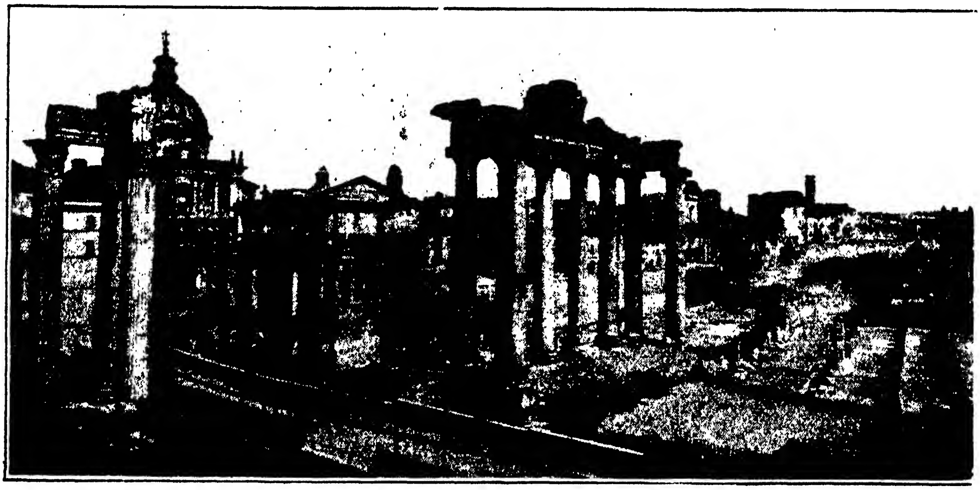
33. AUGUSTUS CÆSAR *Anderson*
The Vatican Museum, Rome

the element of pure beauty into their imposing buildings. By slight modifications of the Corinthian order they arrived at the Roman or composite order of architecture [see page 2035], in which the chief feature is a rather clumsy combination of the Corinthian acanthus leaves and the Ionic volutes on the capital. The Corinthian and the composite orders were in general use throughout the period of the Roman Empire, though the Doric and Ionic orders were not altogether discarded.

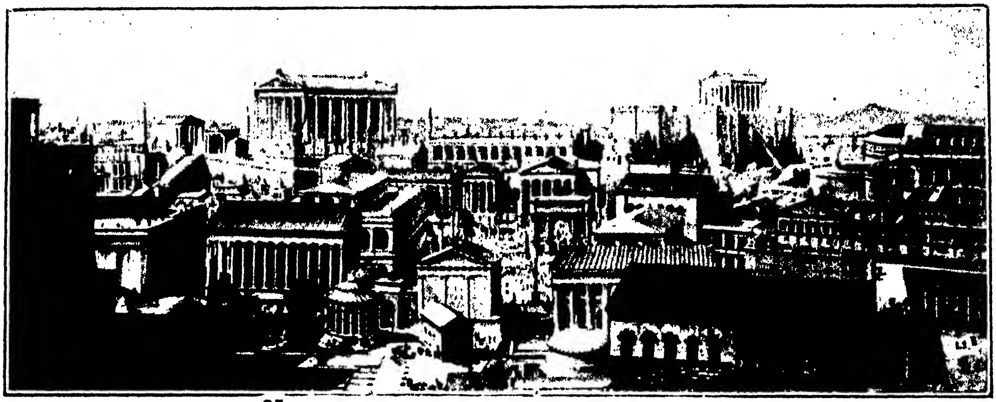
Roman Houses. The excavations of Pompeii give a complete picture of the arrangement of the Roman private houses, which were divided into the public front part and the private apartments at the back of the building, each grouped around an open colonnaded court, the atrium. The walls were richly decorated with fresco paintings, the floors with mosaic inlay. The basilicas, or public halls for the transaction of business, and perhaps of law cases, are of great importance, if only for the reason that this form of rectangular hall in two storeys, with the wall of the second storey supported by colonnades, was subsequently adopted for the early Christian churches. Though the Romans, in their domestic buildings, neglected nothing that could add to the air of elegance and comfort of their homes, the building genius of this nation, as of the Greek, was chiefly spent on imposing public edifices, on temples, theatres, aqueducts, and public baths.

Roman Sculpture. The art of sculpture in the days of ancient Rome was merely a continuation, or rather a revival, of Greek sculpture. The Romans, ever greater in appreciation than in creation of works of art, loved to surround themselves with good copies of famous Greek statues ; and, in fact, until the genuine works of Hellenic art became known during the last century, our knowledge of the masterpieces of ancient Greece was entirely dependent on Roman copies, or rather copies made by Greek sculptors for Roman clients. Such original works as the famous Medici Venus [page 184] are remarkable for their purity of form and melodious rhythm, but lack the naïve sincerity and the pulsing life of the finest achievements of Greek art. This and kindred works still bear the characteristic stamp of Greek art, but in plastic portraiture Rome introduced a new conception of art.

The subjects with which Greek sculpture had been almost exclusively occupied demanded a certain idealism. In representing actual human



34 THE ROMAN FORUM



35. THE CAPITOLINE HILL AND ROMAN FORUM *Anderson*
From the restoration by M. Joseph Gatteschi, Rome. By permission

individualities the sculptors of Rome aimed at character rather than beauty, and arrived at a sound, healthy realism of extraordinary vigour. In the full figure, as in the superb marble statue of Augustus [33], they retained something of Greek dignity and elegance; but in the heads, in the countless marble and bronze busts of emperors, every other consideration had to cede to the desire of life-like realism.

Relief Carving. The relief carvings on the Roman sarcophagi belong to a late period —a period of decline—and are generally the more or less mechanical work of skilled craftsmen who were content with repeating again and again the same composition. In every respect they are vastly inferior to the remarkable reliefs on the Column of Trajan, an excellent cast of which is to be found at the Victoria and Albert Museum. Nevertheless, these sarcophagi were of the greatest importance to the history of art for the stimulating influence they were to exercise after many centuries on the Pisan and other sculptors of reawakening Italy.

Paintings. Like sculpture, painting in Rome was derived from Greek sources, though in this branch of art the Romans were not entirely dependent on Greek executants, since we know the names of some native Roman artists who flourished as far back as the second and third centuries B.C. The fresco paintings at Pompeii and Herculaneum are partly the works of Greek painters of the decline, and show considerable differences in artistic merit. They depict scenes of daily life, generally with strikingly graceful figures, or mythological compositions, many of which are probably inferior copies of Greek masterpieces. The colouring is light and tender, the modelling at times merely indicated, and at others carefully worked through. The Aldobrandini Marriage, at the Vatican, a fresco of the Pompeian type, is perhaps the most beautiful example of the painting of the period [36].

If the majority of the Pompeian paintings are unmistakably Greek in character, there are others which are as distinctly Roman, if we may take realism as the characteristic feature of Roman art. It has been pointed out that certain Roman frescoes are executed in a style not unlike that of the modern impressionists, and that a fresco in the Casino Rospigliosi is so "free in execution that it might easily be attributed to Fragonard." This may be a slight exaggeration, but it is certain that the germ of realism was at no time eradicated from Roman or Italian soil, and that at the time when Byzantine stiffness and formalism had invaded Italy from the Eastern Empire only a slight stimulus was needed for this healthy tendency to reassert itself and to blossom forth in its full power.

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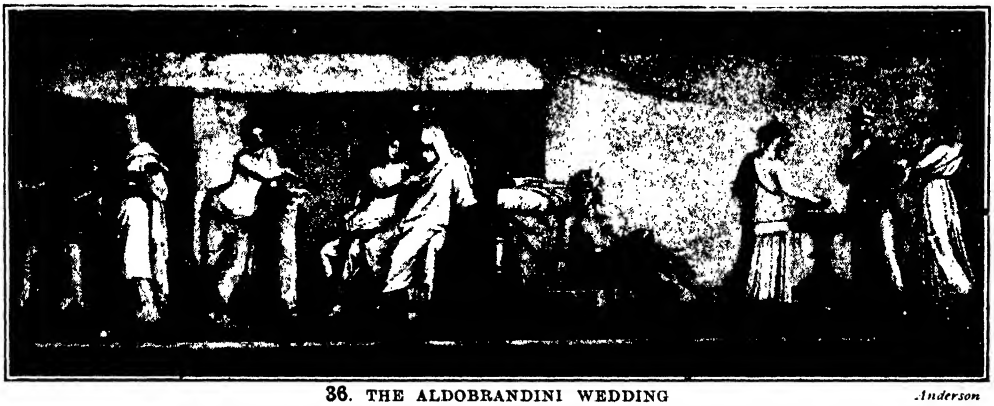


36. THE ALDOBRANDINI WEDDING *Anderson*

DIPLOMATIC & CONSULAR SERVICE

NATIONAL SERVICE continued from page 2811

Attachés and Foreign Office Clerks. Diplomacy as a Career. King's Messengers. Consular Appointments. Interpreterships

By ERNEST A. CARR

ALL the posts of various grades that come within the scope of the present paper are controlled by a most important Department of State—the Foreign Office. Under the direction of a Parliamentary Secretary of State for Foreign Affairs, this branch of the public service is occupied—as its name indicates—with the relations existing between our own and foreign countries. The functions involved are broadly of two classes. Of these the first comprises our political interests—the representation of Great Britain at foreign courts, due enforcement of our prestige, the making of treaties, and the maintenance of such terms with each nation as are dictated by our foreign policy. All these matters are entrusted to our Diplomatic service. Commercial and non-political interests, on the other hand, come under the care of the Consular service. These two divisions of Foreign Office work are not always separate in practice, but for convenience' sake they will be separately discussed here.

THE DIPLOMATIC SERVICE

Political diplomacy as a career is carefully reserved for the chosen few. For all appointments in the service a nomination by the Foreign Secretary is essential, and this is awarded only to aspirants of high social rank and liberal education, who have given promise of special abilities to fit them for the intricate and delicate rôle of the diplomat. The most ardent supporter of the principle of unrestricted competition as a means of recruiting our public services will, we believe, be convinced on reflection that such a system, however admirable in itself, would be out of place in the Diplomatic circle. For that calling, while brains are invaluable, the ability to pass examinations is comparatively unimportant. The type of officer required is not the bookish student but the clever, well-educated man of the world, who is also, in the conventional sense of the term, a polished gentleman. The supreme essentials for success, in fact, are tact and shrewdness, a wide knowledge of men and affairs, and such a social standing and personal address as will procure an entry into the highest circles of any foreign capital to which the diplomatist may find himself appointed. And such qualifications are best secured, not by competitive examinations, but by personal selection among the scions of our leading families, from which class the members of our Diplomatic service are generally drawn in fact.

Candidates who are fortunate enough to obtain a nomination from the Foreign Secretary compete, as vacancies arise, for the interchangeable appointments of junior clerk in the Foreign Office and attaché in the Diplomatic service. From half a dozen to a dozen such vacancies are offered each year, and are contested by three or four times as many candidates.

Attachés and Foreign Office Clerks. Under the present scheme the limits of age are 19 and 25. As one might expect, great prominence is given in the examination to foreign languages. In addition to the ordinary English subjects, with précis writing, the history of Europe, and general intelligence, the obligatory papers include French and German, and the optional section consists of any two of the following: Italian, Spanish, Portuguese, Russian, and Latin. The test in respect of each modern tongue is very severe, including extempore translation, reading manuscript, writing a letter, and a political or commercial essay in the language, and a viva voce examination in which particular stress is laid on accent and grammatical accuracy. The paper on European history covers the period from 1789 to 1880, and includes the related history of Asia and America. General intelligence is tested specifically by the quickness candidates display in seizing the points of papers read to or by them.

After July 1st, 1907, the existing scheme will be abolished, and the lower limit of age raised to 22 years. Nominated candidates will then compete among themselves at the examinations for Class I. clerkships held in August of each year. [Particulars of this examination were given on page 2269.] They will be required, as before, to pass in French and German, and are officially notified that they "must reach a high qualifying standard in translation, composition, and oral examination in both these languages," and that Spanish may be taken as an alternative to Italian. With these modifications the Class I. scheme will apply.

Salaries and Prospects. Successful candidates who enter the clerical staff of the Foreign Office enjoy practically the same advantage as Class I. clerks, rising rapidly to £800 or £1,000 a year, with special allowances for translating and other work, and some prospects of higher posts. Those who are destined for a diplomatic career must have ample private means, as they are required to serve for some years on honorary or merely nominal terms. Their ultimate prospects, however, are more brilliant and distinguished than any other branch of the public services can afford. They are first appointed on probation as unpaid attachés for two years, and then receive commissions as third secretaries at £150 a year. This amount may be augmented by special allowances of £100 each for proficiency in the native language and in public law. On promotion

to the grade of second secretary they are paid £300 rising to £450, and after seven years' service in that rank become first secretaries at £500 a year. From this point advancement is rapid to the foremost positions; but as the salary and status of a British representative abroad vary with the importance of the country in which he serves, no strict classification is possible. Councillors receive from £500 to £1,000 a year, ministers and envoys between £1,300 and £5,000, and ambassadors from £5,500 to £9,000. In Peru and Venezuela, for instance, we are represented by ministers-resident at £2,000 a year each, in Portugal by an envoy-extraordinary and minister-plenipotentiary at £3,750; while in the capitals of such first-class Powers as Germany, Turkey, and Russia, we have ambassadors stationed who receive for their services from £7,800 to £8,000 a year. The premier position in the service—that of British Ambassador in Paris at £9,000 a year—is held by a distinguished diplomatist who began his career as a Foreign Office clerk.

King's Messengers. A small force of Foreign Service messengers is employed for the conveyance of confidential despatches between headquarters and the embassies. This work is responsible and sometimes not free from perils. The messengers are therefore chosen with the utmost care from among skilled horsemen of hardy frame and proved courage and devotion. Several of them have held commissions in the Army. They are paid from £250 to £525 a year. Candidates must be between 25 and 35 years of age, with a good colloquial knowledge of French, German, or Italian. When actually bearing despatches the King's messengers wear a picturesque badge—a silver crown and greyhound suspended by a blue ribbon.

THE CONSULAR SERVICE

Apart from honorary consulates and those held by traders—with which appointments we are not concerned here—the Consular service is maintained by means of examinations of three classes. Of these the first is for student interpreterships in the Ottoman dominions, Persia, Greece, and Morocco; the second, for similar positions in China, Japan, and Siam; and the last, for general consular posts other than interpreterships.

Student Interpreterships. This grade was created in order to supply His Majesty's missions and consulates in the East with trained officials, speaking and writing the native languages, and competent to perform the legal and other duties of consular officers. It is, of course, imperative that the man selected should have considerable aptitude in acquiring languages; for which reason foreign tongues are prominent among the subjects fixed for the entrance contests.

For interpreterships in the Near East—the Ottoman Empire and neighbouring lands already named—the examination scheme and the subsequent training differ very materially from those prescribed for the joint service of China, Japan, and Siam. The former branch, for instance, is entered by means of open competition; for the latter a nomination is essential. But before discussing in detail the separate schemes we may note such conditions as are common to both.

The age limits for either service are 18 and 24, candidates who have served on actual military duty being allowed to deduct from their age any time thus spent. The requirements as to physical health are specially searching in each; and for both sections there is the same provision as to nationality: "Persons not actually born within the United Kingdom, or born within the United Kingdom of parents not born therein, will be allowed to compete only by special permission of the Secretary of State." The examination fee in either case is £4.

Interpreters in the Near East. For the Turkish dominions, Persia, Greece, and Morocco, student interpreters are selected by means of open competitions held at intervals of about 18 months. Very few vacancies are offered at a time, the number in recent years having never been more than six. Luckily the candidates are also few. They rarely much exceed a dozen—several of whom usually fail in Latin or French. Such a small attendance is due to the fact that very few men are sufficiently expert linguists to face an examination in six foreign languages at once. That formidable array of alien tongues awaits aspirants for the Near Eastern service; and although four of the half-dozen are nominally optional, a glance at the accompanying table, which includes the results of a recent test, will show that a competent knowledge of each is essential for success.

EXAMINATION FOR STUDENT INTERPRETERS: TURKEY & NEAR EAST

			Obligatory.				Optional.			Total.
Max. .	300	200	200	600	400	400	300	300	300	
No. 1	290	160	122	503	304	293	204	243	257	

The test in French is severe, including translation from and into the language, dictation, writing a letter in French, and conversation—paying particular attention to accents, genders, and tenses. In all, the various foreign languages are responsible for no less than 2,300 in a total of 3,000 marks.

Students who are declared successful at these contests are sent to a university on probation for two years, pursuing there a prescribed course of studies in Oriental tongues and spending a month of each year in France. During the term of residence they receive a salary of £200 a year, subject to their passing their examinations from time to time. On quitting the university they are appointed as assistants at a salary of £300 a year, and are despatched to a British consulate or legation in the East. Twelve months later they are examined in the language of the country in which they reside, and after a further interval must pass an examination in law and history. On the results of this final test their seniority in the service depends.

Thenceforward the much-examined consular servant is suffered to pursue his career without further molestation. It is a fairly but not extravagantly remunerated calling. On becoming a vice-consul, the ex-student interpreter receives from £350 to £450 a year, with fees and allowances which are in some cases very substantial. The higher grades of consul and consul-general carry salaries of from £600 to £1,300, in addition to allowances as before; and for those who win the special favour of the authorities at the Foreign Office there are chances of transference to still better-paid posts.

The Far Eastern Service. Until a few years ago, student interpreters in China, Japan, and Siam were appointed on the results of open contests; but in 1904 the system of limited competition was introduced instead, candidates being nominated to compete by the Secretary of State for Foreign Affairs, to whom they must be influentially recommended.

The examination subjects, as well as instances of the marks that secured appointments at the only competition held as yet under the new scheme, are shown below:

EXAMINATION FOR STUDENT INTERPRETERS IN CHINA, JAPAN, AND SIAM

	Obligatory.			Optional.			Total.
Max. .	200	200		200	400	300	
No. 1	200	132					2,072
No. 10			131	127			1,750

Though this syllabus covers a wider range than in the case of appointments in the Near East, the ordeal is, in reality, far less trying. There are but three foreign languages instead of six, and the legal subjects included in the scheme are less formidable than they appear, and can fairly easily be "crammed." In the regulations issued by the Civil Service Commissioners the scope of these latter papers is thus defined: (*a*) The elements of criminal law. (*b*) The principles of British mercantile and commercial law relating to (1) shipping; (2) negotiable instruments, bills of exchange, and promissory notes; (3) contracts for the carriage of goods; (4) contracts for marine insurance, bottomry, and respondentia; (5) contracts with seamen; (6) the doctrine of stoppage *in transitu*, and lien.

On passing the examination, student interpreters proceed directly to China, Siam, or Japan, where they spend a probationary term in studying the native language, receiving, meanwhile, an allowance of £200 a year. On completing their studies they are appointed as third-class assistants in a consulate at a salary of £300. Thence they progress through the grades of second and first class assistant (£350 and £400), and vice-consul (£600 and £700), to the leading position of consul (£800 to £1,200). The abler linguists among the assistants receive special grants for interpreting and translating duties; and in the higher grades there are liberal allowances of various kinds.

General Consular Appointments. In 1904 the Foreign Secretary formulated a general scheme for recruiting the Consular service by the admission of nominated candidates other than student interpreters. Anxious to attract young men of good standing and of some legal or commercial training, the authorities have announced that any of the following qualifications will be of service to candidates when seeking the Foreign Secretary's nomination: admission to the Bar or as a solicitor, a university degree, or three years' experience in a commercial house.

Until January 1st, 1907, the age limits for candidates are 22 and 30 years; on that date the upper limit will be reduced to 27. Persons nominated to compete are examined in English, French, either German or Spanish, commercial law, arithmetic, commercial geography, and political economy, and must qualify in every paper. A detailed syllabus of these subjects can be obtained on application to the Under Secretary of State, Foreign Office, S.W.

On passing their examination, candidates are at first employed for several months in the Foreign Office and the Board of Trade, to learn the methods of business in those departments. They then proceed to their posts abroad. After a year's foreign service they are expected to know enough of the local language to be able to communicate directly with the natives. This test being met, the consulate officers become eligible for advancement in the same way as are student interpreters. It is as yet too early to compare with any certainty the prospects of promotion in these two grades.

Continued

THE CHOICE OF BOOKS

The Importance of Reading Good Books. Reading with a Definite Purpose. Books for Pleasure and Profit. When and How to Read

By HAROLD BEGBIE

"THERE are books," says Emerson, "which take rank in our life with parents and lovers and passionate experiences; so medicinal, so stringent, so revolutionary, so authoritative—books which are the work and the proof of faculties so comprehensive, so nearly equal to the world which they paint, that, though one shuts them with meaner ones, he feels his exclusion from them to accuse his way of living."

It is with books of this character that the reader should have to do. For reading, be it remembered, is thought, and, as Professor Bain says, "the fact is now generally admitted that thought exhausts the nervous substance as surely as walking exhausts the muscles." To waste, therefore, our nervous substance on that which makes no adequate return in delight is a profligacy compared with which the excessives of the spendthrift are but a mere folly.

We must be careful not to waste ourselves on those merely "popular authors" against whom Maurice de Guerin was never weary of inveighing—those authors "whose names appear once and disappear for ever; whose books, unwelcome to all serious people, welcome to the rest of the world, to novelty-hunters and novel-readers, fill with vanity these vain souls, and then, falling from hands heavy with the languor of satiety, drop for ever into the gulf of oblivion; books which have in them not one grain of the hidden manna, not one of those sweet and wholesome thoughts which nourish the human soul and refresh it when it is weary."

Reading with an Aim. At the outset, then, our aim must be to exercise a definite selection in our choice of books. Out of the millions of books which have been written, and are now at this moment being written with furious pens in every city of the world, we must be careful to choose only those which contribute definitely to that unity of character which we must suppose to be the goal of every intelligent person. To read a book because everybody is talking about it, or to read a book because everybody read it in the last generation, or in the reign of Elizabeth, is a foolishness. We must know accurately what it is we desire to read, and only read such volumes as seem to promise a contribution to this end.

It is not our object here to supply a list of the hundred best books. The student will never have to seek far for authorities with ready-made lists of books which it is essential for him to read. Our object is rather to suggest, in a general way, the spirit which should animate a student in selecting the books for his reading. And we declare that the first thing essential is a conscious object in our reading. We must know whether we are reading for the idle purpose of passing time; whether we wish to improve our minds in a general way; whether we are seriously devoting ourselves to one particular study, and so on.

A Regular Course of Study. Given this conscious aim, our next step is to make out for ourselves a regular course of study. We must exercise as wide and certain a judgment in directing our reading as a horse-trainer exercises in the breaking of a colt. No horse-trainer, we mean, would leave it to the moment to decide whether the colt should go out with a dumb jockey or a saddle on its back; he would not let the inclination of a moment decide whether the animal should be lunged or go into a cart. There are steps in the breaking of a colt; there are steps in the training of the mind. Only by proceeding in a settled and determined manner can we hope to succeed in our intellectual undertakings.

Let us take an instance of what we are now arguing. Suppose a man to be educating himself in theology. He will never arrive at any coherent opinion on the matter if he begins with Renan, proceeds to Strauss, then discovers Priestly, and finally hears of Duns Scotus and Thomas Aquinas. He must begin at the beginning; must, indeed, go far back beyond Neo-Platonists and Apologists, and acquaint himself at the outset with some certain notion of Greek philosophy. He must know, that is to say, what it is the theologians mean when they speak of God and of the soul. His course must be clear before him. He must know what views were prevalent before and at the period of Christ's appearance, and then he must struggle to follow through history the influence of pagan philosophy and new ideas generated by new times on the teaching of Jesus.

In a simpler matter, we may take the man who is desirous of making a study of humour. He must be careful not to read now a book by Mr. W. W. Jacobs, now a satire of Swift, now an Elizabethan comedy, now a novel by Smollett, and now a story by Mr. Hall Caine. As well might a sea-captain hope to go from Liverpool to New York by making first for Hamburg, then for Dover, then for Singapore, then for Cherbourg, and then for Sydney.

The Harm of Desultory Reading. Desultory reading is the great preventive of knowledge. If we read an essay by Matthew Arnold, then an article in the Encyclopædia Biblica, then a chapter of Carlyle's "French Revolution," and then an essay by Ruskin, we shall know at the end of our reading, owing to the confusion of ideas, rather less of literature, theology, history, and art than when we set out with such praiseworthy efforts to improve our mind.

It has been pointed out by some philosophers that to understand a subject, or even an aspect of a subject, we must read several books concerning it, books arguing diametrically opposite views, perhaps, and read these books, too, without any interruption from books of another character.

There are books, however, which are good at all hours, and whose delight is above all laws. A novel by Balzac, or Thackeray, or Dickens, or Scott, or Dumas, is like the air we breathe, and "may be taken with solid food." These are the books which a man may read as refreshment, as recreation after stiffer reading, and yet do their authors no dishonour. They are books which bring forgetfulness, and re-create mental energy. They take nothing out, but pour into us a new source of energy—a joyousness, a rapture, a content. We go to them to be amused and delighted, and they never fail us.

And yet it is surely desirable that a man should not "make a beast of himself" with this delicious provender. It is not a good thing to eat perpetually of the same food. We may well envy the people who lived at the period of their production, and who had to wait a year, or perhaps two years, for the next book of their favourite author. With all their volumes on our shelves, it is difficult not to go on reading book after book till we are sated by them, and, by the same token, have acquired no aptitude for books of deeper meaning. Because of their very richness, they should be used with discretion.

Opportune Time for Reading. There are people in the world, apparently people of some saneness, who will tell you that they cannot read Dickens, or Cervantes, or Fielding, or Walter Scott. The beginner may find the same trouble with himself: but let him not despair. It is a curious thing, but a book requires a certain psychical condition on the part of its reader; probably it is a subliminal receptivity of which psychologists are not yet aware. The writer remembers as a boy being begged to read "Ivanhoe," and manfully, again and again, trying to do so, being unable to get further than yawning over the conversation of the swineherd and the jester. Years afterwards he sat up reading "Ivanhoe" through half a night, unconscious of aught else in the universe besides the magic of Sir Walter Scott; and from that moment he numbered himself humbly among the glorious company of his admirers. It is the same with other books, and other authors. At some moments a book on philosophy or science will seem inexplicable, the sentences laborious efforts at confusion, the thesis of the writer utterly unintelligible. The next day the same book may have the lucidity and the charm of a novel, and carry one forward without mental effort from the first page to the last.

We venture, then, to caution the reader against trusting any first disgust of a writer whose name is starlike. How many unhappy people are there in the world who have never had the joy of reading "Beauchamp's Career," "Rhoda Fleming," "Sandra Belloni," and "Richard Feverel," because on one particular occasion they found "The Egoist" a mental puzzle beyond their power?

An Essential Book. There is one volume concerning whose quality the wise man will exercise the greatest care; we speak of an English dictionary. It is the opinion among too many people that a dictionary is only useful for hunting up the meaning of an obscure term, or even for verifying the spelling of a word. This is a mere nursery opinion. A good dictionary, such, for instance, as the famous Century Dictionary, is a work deserving of the closest study. It teaches one, in some degree at least, the history of words—that wonderful evolution of human speech which is among the most fascinating of our studies. Well would it be if more people made a hobby of word-history, and, in place of postage stamps and birds' eggs, collected interesting instances in philology. But as it is, the man who takes himself seriously will, at any rate, learn to differentiate between a dictionary and a time-table.

Among the "reference books" which we may recommend to the care of the student is that interesting compilation described as "Roget's Thesaurus of English Words and Phrases." In a volume of this kind the student not only finds synonyms for his own efforts at composition, but learns in how many various ways a single word may appropriately be used. Wide reading and a good memory, of course, render such a volume unnecessary, but the young student should not be without it. All his reference books should be the work of scholarship, and they should not only be consulted in emergencies, but occasionally read for the interest of their information.

Emerson's Three Rules. In conclusion, the individual is wise who is careful so to arrange his course of reading that works of the imagination are clearly separated from works of science. He must, of course, read both Wordsworth and Mill, both Shelley and Professor Bradley, but he must read them at different times with some interval for the brain to adapt itself to the change. The brain that has been following Aristotle's reasoning is not ready to mount skyward with Shelley, and the brain that has been breathing heaven's air with Shakespeare is not ready for the subtle analysis of Darwin.

Finally, to end with Emerson, even as we began with him, these are the three rules of that powerful mind: (1) Never read any book that is not a year old; (2) never read any but famed books; (3) never read any but what you like; or, in Shakespeare's phrase:

"No profit goes where is no pleasure ta'en:
In brief, sir, study what you most affect."

The reader, however, will take Emerson's advice with the remembrance in his mind that the will can be educated to take pleasure in a study that once was irksome. If we read only what we found pleasure in at twenty we should be fools indeed.

Continued

PRINCIPLES OF TEXTILE DESIGN

Aims in Design: Utility, Durability, and Beauty. Plain Cloths, Cords, Twills, Satins, and Double Cloths

Continued from page 2898

By W. S. MURPHY

Fabrics. A textile fabric is an extended substance formed by the intersection of fibrous threads as thick as the combined diameters of the threads lying above one another. This definition may seem very general and perhaps abstruse, but we have to cover a wide variety of fabrics. Brussels carpets and silk gauze, linoleum and lace, are equally textiles. Some authorities say that laces are not textiles, but we shall see that no such line of distinction is possible, the muslin weaver and the lace-maker often crossing the one into the territory of the other. The business of the textile designer is with those intersecting threads. He has to say in what manner and in what order they shall be combined.

Utility. When we speak of design, the imagination is apt to run upon art lines, and form visions of figure and colour, picture and ornament. But the facts of everyday work severely contradict the imaginative tendency. Ornament is not the first object of textile design. The primary duty of the designer of fabrics is to scheme a useful commodity. Utility is the basis of textile production. Clothes are meant to cover the body, preserve its natural heat, and protect it from external heat or cold. Carpets and floorcloths conceal the floorings of rooms, and present a smooth or soft surface to the foot. Even such fabrics as lace and gauzy draperies are primarily useful, and intended to screen or veil the objects before or on which they are hung.

Durability. A very important quality of textile fabrics is durability. Cloth of every kind is subject to varying degrees of friction and strain, and, in designing, we are called upon to endow the fabric with the requisite wearing quality. The structure must stand the stress of use. Some fabrics are subject to friction only, some bear tensile strain only; but most textiles have to suffer both rubbing and straining. Wearing qualities largely depend upon the kind of threads used and the way they are put together. An important part of the designer's work is to see that threads are disposed so as to offer the strongest resistance to friction or stress.

Ornament. Having obtained fitness and durability, we may go on to ornament. Here the utilitarian is bound to concede a little to the artist. The addition of certain forms of ornament strengthens fabrics; or, to put it another way, some patterned cloths are stronger than the plain cloths of the same class. On the other hand, figures and patterns, if formed out of the substance of the fabric, may weaken it considerably. Colour, if properly applied, has little or no effect on the wearing quality of cloth, and otherwise enhances its value. There is no reason why, in nine cases out of ten, a dyed thread should not last as long as a grey one. Certain shades of brown, and one or two dyes, weaken the thread slightly and form the exception to this rule. Colour is the main source of textile ornament, and the student should pay attentive heed to the dyeing section of our course. Every kind of textile has its own canons of art. What might be appropriate in fancy cottons would be out of place in carpets or woollens.

Warp and Weft. We have said that textile fabrics are composed of crossed and combined threads. As a rule, the cloth is built together by the interlacing of longitudinal threads called *warp* with the traversing threads we call *weft*. The warp is in the loom, and the weft is in the shuttle. The relations of those two constitute the design of the fabric. As we have hinted, there are exceptions of a complex nature; but these may be left out of account meanwhile. We name the warp threads the *ends*, and the weft threads are *picks*.

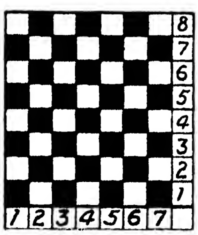
Varieties of Threads. In the study of textile design we have to consider the various kinds of threads which may be used. In the foregoing part of our course we have studied the making of fibres into yarns, and have seen cotton, woollen, worsted, flax, hemp, jute, ramie, and silk threads reeled into hanks for the weaver. The possibilities of variation in each one of these fibres are very large. We may have many degrees of soft spinning in cotton and other fibres, and lightness of twist in silk; on the other hand, the degrees of hardness to which we may spin are equally extensive. The counts of yarn run in cotton from 10 hanks to the lb. up to 300, or even higher, and in all the other fibres we can obtain a range which, though less, is still considerable. Without going too deeply into this maze of differences, we shall lay down a few general principles which should constitute a ground-plan of the labyrinth.

Designer's Paper. Pointed paper, designer's paper, squared paper, and lined paper are the various names given to the kind of paper [117] upon which designers work out their schemes. It gives a very useful aid to the student. We must always remember that no point in any textile design can be smaller than the square of the diameter of the thread used. This fact gives a certain stiffness to all designs worked out in thick threads, such as woollens and carpets. The transition from colour to colour is very marked, and delicate shading is very difficult. Sometimes artists draw out designs or schemes of colour on ordinary drawing-paper, and, if accepted, the pictures are put on to pointed

paper by the factory designer. But the more satisfactory way for all concerned is to encourage the textile designer in artistic effort, and so have the picture shown as a weaving scheme at once. It may be that a design from an artist without textile experience works out all right up to a certain point and then baffles the most ingenious effort to get it within the scope of the loom. Much valuable time and labour has thus been wasted through the fault of nobody.

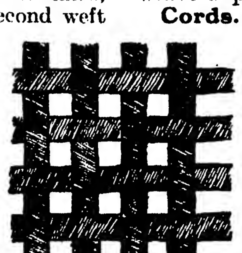
It is difficult to present a clear picture of designing paper [117]. The squares are all the same; but if we take it that, read vertically, the squares represent warp threads, and read horizontally, weft threads, some idea may be gained [118]. Warp and weft are together at every point of ordinary cloth; the spaces covered by the vertical and horizontal squares are the same; but the question the designer has to answer is—what is to be the order of the appearance of those threads upon the surface? If two layers of thread are put on the same space, the one must lie on the top of the other. The under lot of threads must be hidden, and not a particle of connection is established between the two sets. Let us make the warp threads white and the weft threads black. So long as the warp threads are uppermost, our squares are white, and a black square indicates where a weft thread comes up. Having secured means of identifying the two sets of thread we propose to combine, we can now proceed.

117. TEXTILE DESIGN PAPER



118. DIAGRAM OF PLAIN CLOTH

Plain Cloths. Weaving is a continuous flat plaiting. For instance, suppose we take eight slips of paper, four to represent warp, and four weft. Lay the warp slips lengthwise in a row. Take a weft slip and insert it under the end of the first warp slip, over the second, under the third, and over the fourth. With the second weft slip reverse the order, passing it over the first warp slip, under the second, over the third, and under the fourth. Plait the third weft slip like the first, and the fourth like the second. Now we have a fairly solid square of plaited paper, the component slips appearing alternately on each surface. Simple as it may appear, the fact that interwoven slips or threads of any material will form into a unity lies at the bottom of all textile work. In plaiting either threads or paper slips, we bend the one substance over the other, and leave an opening at the bending point. Hold a piece of plain cloth up to the light, and you will see holes in it at the crossing of every thread. A few threads of plain cloth magnified [119] shows this clearly. The thicker and harder the fibres or threads, the wider the openings must be, and the effect of twist [120] is one of the designer's tools. No plain cloth can be absolutely solid. But we have ways of obviating this defect. The thinner the threads, the smaller the openings. By using a soft, spreading thread, we can reduce the opening to a minimum—that is, the soft fibres will spread over and hide the openings. Plain cloths can thus be varied a good deal. We may have thin warp and thick weft, thick warp and thin weft, warp of cotton and weft of wool or worsted, warp of worsted and weft of silk, and many other variations, while the weaving action remains the same.



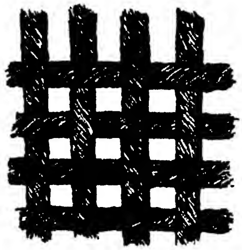
119. PLAIN CLOTH

Yarns in Cloths. The relations of warp and weft should be closely investigated to begin with. Plain weaving does not necessarily mean plain cloth. Hence some confusion has arisen in trade terms. Poplins and cords are not plain cloths, but they are plain weaves. Leaving out of consideration for the moment the different materials of which warp and weft may be composed, let us look only at their relations in regard to thickness. In the best class of what we may call poplin weaves, the weft threads are thicker than the warp threads. On the other hand, there needs be more warp threads to the inch than weft threads. Observe the inevitable effects [121]. The thick weft threads are too heavy for the slender warp threads to bend; but one must bend, and it is the warp. The weft lies straight. But because the close warp bends round the first thick thread of weft, the second weft thread cannot get up close to its neighbour, and so the ribbed appearance of the poplin weave is produced.

Cords. Another way of producing a pattern, or variation, on a plainly-woven cloth is by reversing the proportions in the thicknesses of the warp and weft. A fine, thin weft is helpless against a thick warp, and therefore must do all the bending. In doing so it forms a slender barrier between one warp thread and another, producing the fabric we call *cord*.

Specific Nature of Plain Weaving. From these instances the student will learn that the one quality which distinguishes what are technically called *plain cloths* is the interweaving of every thread of warp with every thread of weft. Any departure from that order is not plain weaving. This fact has to be very firmly grasped, or we

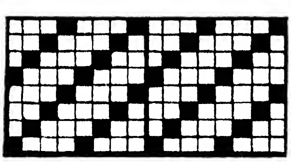
may find ourselves in confusion. For example, in some districts the species of "cram" which produces reps has been classed with plain cloths. It is true that the three or more fine threads of the heavier reps are put through one dent, or head, in the reed, and thus appear as one thread, on which the weft interlaces alternately; but it is a fancy weave, because of the introduction of the combined warp threads, and if that be allowed to pass for plain work, it is hard to say where we could stop.



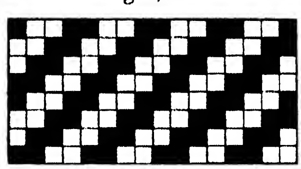
120. EFFECT OF TWIST IN CLOTH

Twills, or Twilled Cloths. We have seen in poplin the warp threads laid close together and the weft threads held apart. In cords, on the other hand, the weft threads are close and the warp threads are separated. Now, it seems possible that those two opposites may be combined and afford a perfectly close fabric. The closer fabric will necessarily be heavier, and, other things being equal, stronger. Plain weaves, however, give very little scope for ornament. After we have alternated two warp threads with two weft threads, our pattern is finished, and the possible variations can be shown on four squares of pointed paper. Advancing a step further, we attempt a pattern involving six threads, three of warp and three of weft. Pass the weft thread over the first two of warp and under the third; pass the second weft thread under the first, over the second, and under third warp threads; pass the third weft first, and under the thread over the other two warp threads. Repeat this over a web, and you will find that it shows diagonal lines. This is named *three-end twill*, and is commonly seen in cashmeres and similar fabrics. The eight-thread twill, of which we give a design [122], illustrates the principle.

121. SECTION OF CORD CLOTH



122. DESIGN FOR TWILL CLOTH

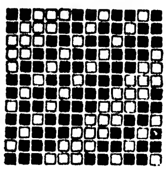


123. DESIGN FOR TWILL CLOTH

Before going further, we may inquire what effect this method of weaving has upon our cloth. In the case of three-end twill we have only one bend for two warp threads every alternate pick. The component threads of the web must, therefore, lie closer, and let us put more into the inch of cloth. The cloth is heavier and more compact.

Diagonal Cloths. Having discovered the advantage of changing the interweaving of warp and weft, we have the right to proceed a little further in the same direction. If the order of interweaving eight threads can be changed, it follows that the variation in a larger number of threads will be greater. This is the principle on which the cloths we name *diagonals* are formed. Here the weft thread passes alternately over and under two warp threads, and the warp thread passes in the same way over two weft threads. But if that were all, we would have made no advance. Each weft thread does not pass under and over the same two ends, nor does each end pass under and over the same two picks. The first weft thread, or pick, passes over ends No. 1 and No. 2, the second pick passes over ends No. 2 and No. 3, and so on, each pick advancing one end [123]. In like manner, the warp threads divide the weft, moving one forward in consecutive order, while all the time combining with two threads. The effect of the regulated change is to produce a diagonal pattern on the surface of the cloth.

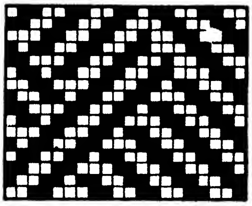
Variation of Twill. Within reasonable limits, it is possible to make any breadth of twill. It is common to see four warp and four weft threads appearing alternately on the surface of a cloth, the principle of shifting the range, of course, being maintained. This pattern could be worked out with sixteen threads, eight of weft and eight of warp. But, suppose, instead of four up and four down, we elected to have one up, one down, and three up and three down, a neater pattern would result, and a firmer though not so heavy cloth. This opens up before us a possibility of wide variation in pattern. The twill structure forms a diagonal line; but it is easy to alter the twill so as to change the direction of the lines. In this way, checks, stripes, or figures may be formed by simply altering, according to design, the direction of the twills [124, 125 and 126]. Elaborate as many of these patterns may seem at first sight, the student, by analysis, can reduce them to simple forms, or diverse repetitions of simple twills. One caution must be given here. There is a limit to the extension of warp over weft or weft over warp—a point at which the crossings partake of the nature of floating threads. Short of that danger, the designer has ample scope for ingenuity and artistic taste, and there is no reason why the danger-line should ever be approached.



124. DESIGN FOR TWILL CLOTH

Satin Twills. It is commonly supposed that broken twills, or satins, are made solely for ornament. But a beautiful cloth may also be a specially strong cloth. A familiar example is the five-thread broken twill [128 and 129]. To view this properly, and get a clear understanding of the principle, let us suppose that a regular twill of five ends has been made, three weft and two warp threads crossing in the usual way. In this twill there are always two adjoining threads crossing. The character of broken twill is the opposite; no two succeeding picks of weft interweave with adjoining ends. To accomplish

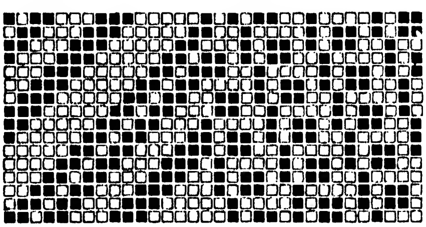
this, we take the number that will not divide into five—the lowest number, that is—which is two. The points of interweaving should, therefore, be two threads apart [127]. Carefully cut up your twill pattern into warp strips, and rearrange them so that no two threads interwoven shall come close together. Warp thread No. 4 will lie along thread No. 1, thread No. 2 will be next, thread No. 5 next, and thread No. 3 last. This principle extends over the whole range of patterns. Advancing to a point where the whole method can be viewed at once, let us take a pattern involving sixteen ends [130] and rearrange it [131]. We obtain a new and pretty pattern.



125. DESIGN FOR CHECKS AND STRIPES

Several objects may be attained by means of the broken twill—added strength, either in warp or weft, smoothness of surface, and ornament. If the weft is thrown on the twill surface more threads of weft to the inch can be put in; warp predominates in the opposite case. When a smooth surface is desired, the number of threads of the section thrown up must be further increased, so that the absence of the one, pulled down by the crossing or interweaving thread, may not be perceptible. With regard to ornament, the method of rearranging the lines of the twills obviously gives wide scope for artistic skill. Fig. 135 is a fair example of fancy twill.

Combined Twills. When the student has grasped the simpler forms of twill, and made such practical experiments as are fully necessary for acquiring a clear understanding of their working, he can proceed to the more difficult task of combining twills. Patterns cannot be combined at random; some combinations which might seem to promise well, so far as appearance goes, turn out to be impracticable. Of two patterns to be combined, the one may have more warp or weft appearing on the surface than the other. If the two opposites balance, well and good; but if the differences are irreconcilable, the combination belongs to the category of the impossible. For example, we may combine two five-end patterns, even though the one shows three weft threads up and the other shows three warp threads; the combination would conceivably be artistic, harmonious, and serviceable. But if the one shows only one thread of weft while the other shows three, the student had better leave the combination alone. The difficulty may be obviated, but the beginner only invites trouble very needlessly who ventures on that line without having first acquired experience. One way, it may be said, of obviating the irregularity is to combine the patterns in stripe form, and as the variations thus alternate within small space, the difference is corrected before it has time to make itself felt in the structure of the cloth. The joining of patterns and the completing of patterns of different sizes are the two next difficulties. One rule in regard to the former may be laid down: Never combine so that more threads of one kind appear on the surface at the point of junction than appear elsewhere in the fabric. Respecting the latter point, it is necessary only to find the common measure of both sets of ends. A three-end and a four-end combined would end in twelve; a four-end and six-end would also end in twelve; a five-end and a three-end, on the other hand, could not be completed in less than fifteen ends.

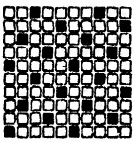


126. DESIGN FOR CHECKS AND STRIPES

Double Cloths. The study of double cloths is one of the most interesting that can engage the mind of the textile student. Having in view its importance and complexity, we can undertake to give only the merest outline of an introduction to the subject. This variety of fabric divides itself, first, into two classes—the one that may properly be called *double-faced* cloths, and the other true *double* cloths. The first class is woven with either two wefts or two warps, and forms a unity throughout; the second has two warps and two wefts, the two cloths being bound at certain intervals. Three motives have inspired the formation of double cloths. Probably, the first aim was to produce a cloth which would combine strength and fineness. To make a heavy, strong cloth with single warp and weft, we must resort to mere thickness of thread, and thickness of thread involves coarseness. By combining three threads on each other, we can employ a fine thread and obtain weight, thickness, and strength. The second aim was to obtain a reversible cloth, so that as one face wore the other could be turned. The last motive was ornament. By an additional warp or weft, the weaver could embellish his cloth in a rich style not otherwise possible.

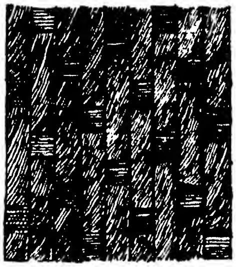
Double-faced Cloths. Naturally, the double-faced cloth offers many alternatives. We may use either two warps and one weft, or two wefts and one warp. We may aim at producing a pattern on both sides, a pattern and backing, or use the backing to add to the complexity of the front pattern. But the question comes—how are we to work two wefts on one warp or two warps on one weft, and maintain regularity of pattern? Let us take, for example, a design for two wefts and one warp [132]. The first object which should be kept in view is the arrangement of the yarns so that each shall perform its own function without interfering with the others. Our best plan is to design each side of the cloth independently, and then learn how the patterns will combine.

This time the combination is different from anything we have yet attempted. Several methods may be adopted, but the easiest is to adopt the broken twill, or *satin* weave [133], which enables the weft to cover up the warp, or the warp to cover up the weft, whichever we please. The principle is very simple, and easily understood. If we have to cover up the warp with weft on one side, it should be no difficult task to cover up the intersection of the weft from the other side with the warp at the same time. A double rule comes here into play. On the one hand the point of intersection of the back weft and the warp must be floated over by the face weft; on the other hand the same warp thread must not be intersected by succeeding picks, either in front or back.



127. DESIGN FOR SATIN TWILL

True Double Cloths. At first glance we might be led into the notion that the weaving of two cloths at once involved no more designing than the weaving of two cloths separately; but the whole value of this most useful class of cloths would be missed were we to run away with that idea. To begin with, we design separately the two cloths to be combined. Having done so, our next duty is to find out at what points the two cloths can be combined. Before we can find out the latter point, we have a good many questions to answer. There are, roughly speaking, four classes of double cloths; first, those in which the two cloths are similar in pattern and equal in quality; secondly, two cloths different in pattern, but of the same quality; thirdly, cloths of different quality and the same pattern; fourthly, those in which the fabrics differ both in quality and pattern. Having in mind the fact that a difference in pattern may alter the relative quantities of warp and weft required, we can see that the problems before us are by no means simple.



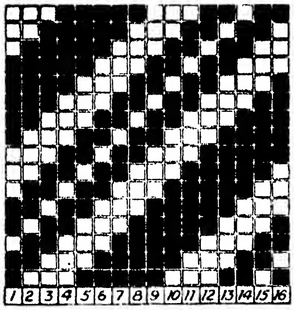
128. SATIN TWILL

Equal Quality and Same Pattern. When designing these two patterns, we are simply making one pattern double the size of the one we intend to weave on each cloth. Suppose it is a four-end twill; the two patterns put together make an eight-end twill. What, then, must be done? The weaving of the loom is to be so arranged that when the weft of the upper cloth is interweaving the whole warp of the lower cloth must be kept down out of the way. Similarly, when the weft of the lower cloth crosses, the upper warp is held up to allow the shuttle free passage. But when the binding point occurs, some modification must be made. That is to say, the warp of the one cloth and the weft of the other must be brought into contact. This is simple. We select the point at which the warp of the upper cloth and the weft of the lower cloth come into close contact in a loose condition, and combine them by interweaving at that moment. In practical work, these points are readily defined.

Equal Quality but Different Pattern. One of the most common forms of this double cloth is the combined twill and plain cloth, the one on one side and the other on the other. We do not undertake to guarantee a good cloth or a cloth of regular structure from the combination. A twill and a plain cloth take up different proportions of warp and weft. Because the warp of the plain cloth is more frequently interwoven than in the twill, and because the weft in the twill can be laid more closely together than in the plain cloth, warp in the first case and weft in the second will be more taken up. But we have to suppose the quantities equal. In ordinary case, the warps are given out from separate beams; the warp of the plain cloth is drawn tight, the weft of the twill is laid on loosely. By this method, and frequent binding, the inequality is overcome, and a good double cloth is produced. We can hardly advise a beginner to attempt this form of cloth unless for some very special object and with a certain knowledge of how it is going to work out.

129. SATIN CLOTH MAGNIFIED

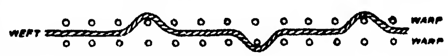
Same Pattern but Different Quality. Practical men sometimes make light of the problems raised by this form of double cloth. Long practice on cloths in constant demand has obscured the difficulties to many workers. Following the practice determined by experiment, designers have been able to produce this class of double cloth by mere rule of thumb. We cheerfully admit that experienced designers can obtain results as good from the methods acquired by long practice as can be got by the most highly educated textile worker alive. But the scientific method ought in some measure to abridge the term of experience needed



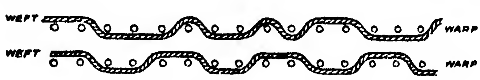
130. DESIGN FOR REARRANGED TWILL

for acquiring the knowledge. Given two cloths of the same pattern, we may count on a regular succession of identical interweavings. This seems easy. But, if we consider the matter on hand carefully, we shall learn that there is an indefinite quantity in the problem. The patterns are the same; but the qualities of the threads differ. How much does this mean? It means that all our calculations may be completely out of truth, if we have not taken account of the latter factor. As a rule, this kind of cloth is made up of a fine fabric on the face and a strong fabric on the back. The difference between the thicknesses of the threads is considerable. We are required to proportion the number of threads in each to compensate for the difference in thickness. Sometimes the thicknesses of the threads do not admit of simple proportion. At least, unless we are on our guard, this will happen. The difference between the threads of the back cloth and the face cloth must be in such proportion that it can be made equal within the compass of the pattern. If necessary, we double, triple, or quadruple the size of a pattern, and it may be done in this case; but the patterns on both sides must end even within a given number of picks and ends.

132. DOUBLE FACED CLOTH—2 WEFTS, 1 WARP

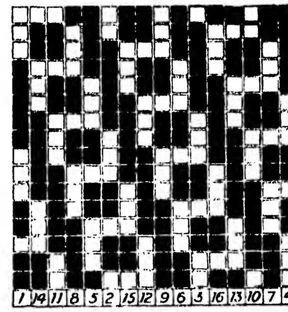


133. DOUBLE FACED CLOTH—2 WARPS, 1 WEFT



134. DOUBLE CLOTH—2 WARPS, 2 WEFTS

Different Patterns and Qualities. This class of cloth comprehends a wide variety, including men's coatings, shawls, carpets, quilts, and many other varieties of figured and fancy fabrics. In its details, the subject is one of immense complexity. To notice even a single specimen of every variety would carry us far beyond the limits of a rudimentary course. The specimen pattern given [134] illustrates most of the difficulties. Fortunately, the principles involved are capable of being studied within short compass. Attention should be specially directed to these four heads: (1) The structure of the face cloth; (2) the suitability of the back cloth; (3) the relation between the thicknesses and pattern of the face and back cloths; and (4) the points of binding.



131. DESIGN FOR REARRANGED TWILL

In regard to the first point, we must insist on the principle that the designer should pay undivided attention to the proper structure of the face cloth as if nothing else had to be considered. A well-conceived cloth, fully worked out in every detail, forms the best beginning possible for a double cloth. Secondly, the back cloth must be adjusted to the face; in the greater number of cases it forms a mere backing. But the back, so-called, is sometimes as important as the face. With the former class we have simply to select a plain or twill pattern which will lie easy to the face cloth. With the latter class we have practically two cloth faces to consider. But the principle of action does not alter. The two cloths must not contradict each other; if twills, the twills must run on lines which fit into one another; if coloured, the combination must always be so that the one does not show through the other. The third point involves calculations which relate to an advanced stage of textile study. But one rule may here be given, easy to understand, and of great use. The thicknesses of threads vary on the ratio of the square roots of the counts of yarn. For example, in adjusting a 40's to a 90's yarn, we would not put in nine threads for every four, but two for every three. The fourth and last point causes the designer of double cloth serious anxiety. As we have seen, the binding should be effected when warp and weft of face and back cloths conjoin, so that neither thread may be deflected too severely from the normal course. If it is the weft of the back cloth which comes up to bind on the warp of the face cloth, the intersection must be at such a point that it will be covered by a floating thread on the surface of the upper cloth.

135. FANCY TWILL CLOTH

Continued

PROGRESS OF EUROPEAN STATES

The Beginnings and Evolutions of Italy, Spain, Germany, Hungary, Russia, Denmark, and the Netherlands

Continued from page 2916

By JUSTIN McCARTHY

ABOUT the time when the Franks obtained the mastery of Gaul, the Ostrogoths accomplished the conquest of Italy. The Ostrogoths came from the East, and, after invading and ravaging much or most of Eastern Europe under their celebrated leader Theodoric, they invaded Italy in 489, and conquered it after a war lasting five years.

Theodoric of Italy. Theodoric proved to be a very capable ruler. He became sovereign of Italy, and reigned there for 33 years. He seems to have given to Italy a time of comparative tranquillity and prosperity very different from its condition in the days of Alaric and Attila.

His life was, however, disfigured by many acts of cruelty. He maintained to a certain extent the ancient senatorial system of Rome, and endeavoured to maintain the institutions which had prevailed when Rome was the mistress of the world. The populations increased under his dominion, and plans were formed for the draining of marshes and the improvement of agriculture. It is told that he did not himself know how to read or write, but he had a great respect for literature and for learned men; he loved to have books read to him, and became a patron of Bœthius, the celebrated Roman philosopher and statesman, as well as of other eminent philosophers. His patronage proved unfortunate for Bœthius, because it roused up against him a host of jealous enemies who prevailed upon Theodoric to believe that Bœthius was devising plots against him. Theodoric yielded to the pressure, and Bœthius was imprisoned, and finally put to death. It was during this imprisonment that the philosopher wrote his famous book "De Consolatione Philosophiæ." Theodoric died in 525 A.D.

Italy Divided into States. Soon after his death the Ostrogoths were disturbed in their possession of Italy by German rulers, and, later still, by Spain and France. Thus the Italian peninsula became broken up into separate sovereignties under various forms of rule, while still proclaiming a common nationality. Italy was made up of several states, the populations of some of which were drawn to a large extent from a foreign and invading ancestry. The states of the Church succeeded to the realm and home of the Roman kings, the Empire of the Cæsars. When the decaying Roman Empire removed its feeble remains to Constantinople, the Papal Power planted its throne in Rome, and has held at least ecclesiastical power there ever since. The regions of Lombardy, the basin of the Po, included the Republics of Milan, Pavia, Venice, and Genoa. There were also the Marquisate of Tuscany and such other states as the Principalities of Capua, the Duchy of Calabria, and the Sicilian island. Each of these states had a history of its own, in letters and art as well as in war, but it was a history broken up by many rivalries, warlike struggles, conquests and reconquests. Some of the great and rising foreign empires and kingdoms made attempts to occupy this or that part of Italy, and throughout the whole of the Middle Ages the peninsula had a very unquiet time. The Papacy continued to be, through these succeeding generations, a great political state as well as a great ruling Church, and its influence was frequently appealed to by disputing sovereigns—foreign as well as Italian—in the hope of obtaining a decisive declaration from the Pope which might bring about a settlement of the dispute.

The Story of Venice. Venice was one of the most famous historic cities of Italy, and her story during many centuries is filled with a peculiar fascination. Venice was founded by populations flying from the fierce invasions of Attila. The first Doge, or Duke of the State, was created in 697 A.D., and not long after Venice began to show a capacity for governing herself as an independent state. In 997 she made herself independent of all the other parts of Italy, and acquired possession of some new maritime cities—Dalmatia and others. The commerce of Venice and her navy increased steadily, and the Republic established the Bank of Venice, which was for ages an important institution in the world's mercantile transactions. The Republic also instituted the picturesque ceremonial in celebration each year of its wedding with the Adriatic—a ceremonial made famous by the poets, romancists, and painters of succeeding generations. The Venetians took an effective part in the Crusades, helping the movement with fighting men and ships.

Naples. Naples was another of the Italian states which made a deep imprint on Italian records. It was, to begin with, the adopted home of a Greek colony who settled there about 1,000 years before the Christian Era. Naples was originally called Parthenope, and the name carries us back into the far-off regions of classic mythology and poetry. Parthenope was one of the three sirens, the sea-nymphs, who had the power of charming by their song all mortals who heard them. When Ulysses and his comrades came sailing by, the Homeric leader, warned against the sirens' fascinations, made his comrades fill their ears with wax so that they might become deaf to the seductive strains. Parthenope,

who had fallen in love with the hero and wanderer, flung herself into the sea because of her disappointment and despair, and her body was cast up on the shore where the foundations of Naples were afterwards raised, and thus the city came to be called by her name. The name of the city was afterwards changed into Palaiopolis —" the old city"—and, later still, Neapolis— " the new city"—and from this we get the name of Naples.

The whole Neapolitan region was conquered by the Romans some 320 years B.C. It underwent invasion from Lombards, Franks, and Germans, and was conquered by the Normans, then occupying Sicily, in 1131 A.D., and made part of the kingdom of the two Sicilies. The kingdom passed about a century after to the German Imperial House of Hohenstaufen, not by conquest, but by marriage, and afterwards went through many changes, to be noticed as we trace the progress of events in Europe. Genoa, too, passed through many political convulsions, in this resembling all, or nearly all, the other Italian states which had at one time made a constituent part of the great Roman Empire.

The Evolution of Spain. Spain, also, went through many successive invasions and conquests from the dawn of her history. The Phœnicians originally formed colonies on the Spanish peninsula, and more lately the Carthaginians, tempted by the riches of her mines, made descents there and founded a new Carthage. Hamilcar, the famous Carthaginian, and on his death his yet more famous son, Hannibal—who took command of the army there—found that to maintain possession of the place they must encounter the Romans. Hannibal therefore crossed the Alps and entered Italy. Then came the Punic Wars, and the long struggle between Hannibal and Rome, ending at length in the utter exhaustion rather than the actual defeat of Hannibal, and, later still, the subjugation of Spain by the Romans. With the fall of Rome, Spain came under the power of the Visigoths, and afterwards the Arabs formed a settlement at Cordova. The Arabs were at that time a source of incessant trouble to France as well as to Spain and Portugal. They were severely defeated at Tours in 732 A.D. by Charles Martel—Martel meaning " the hammer," a name he had well earned by his faculty for dealing hard blows against the invaders of the regions he defended. Charles Martel, the son of an official under the Merovingian kings, had distinguished himself as a soldier, and, more lately, as a commander in the Frankish army, had done splendid service in resisting the Moslem invasion; he completed his work by driving the Saracens out of Burgundy and Languedoc.

The Coming of the Moors. After the Arabs came the Moors. The Arabs still held their own in parts of Spain and in Portugal, but the Christian populations belonging to these regions were all pressing so severely against and around them that they invited the aid of the Moors from Africa. The Moors were then beginning to be a great fighting race, with a genius for seeking new settlements and becoming the possessors of territory. They came to France and Spain avowedly in support of the Arabs, but they soon showed that their especial desire was to drive the Arabs out and let themselves in. They conquered the Arabs, but were defeated in several great battles by the Spanish rulers; and Cordova, Toledo, Seville, and other cities, were recovered for Spain in 1002. Then the Moors fell back on Southern Spain and set up the kingdom of Granada.

Moorish Occupation of Granada. No part of Spanish history is more rich in poetry and romance than that comparatively short period which saw the Moorish occupation of Granada. Christian literature and art have devoted themselves to numberless illustrations of the Oriental splendour which characterised this period of Spain's history; and, indeed, there are so many glorifications of the Granada settlement by European, and especially Spanish, authors, that it might seem as if Europe—and more particularly Spain—felt grateful to the Moors for taking possession of so large a part of European soil and of a Christian kingdom. The famous fortress and palace, Alhambra, was founded by Mohammed I. of Granada about the year 1250 A.D., and its ruins are preserved to this day and visited by admirers from every part of the civilised world. The world also paid, although in a somewhat peculiar fashion, its tribute to the Alhambra glories, for there can hardly be a civilised country which has not its own artistic palace, music-hall, or show-place bearing the name of Alhambra.

The Moors were not able to maintain in perpetuity their occupation of Southern Spain. We may anticipate Spanish history a little, and note in this place the fact that in 1469 Ferdinand II. of Aragon married Isabella of Castile, and that within ten years practically the whole of Christian Spain was formed into one monarchy. The next important event in the history of Spain was the taking of Granada, after a siege which lasted for two years, by the Spaniards, when Ferdinand completed the triumph of his country by the final expulsion of the Moors. Thus we find Spain brought to her established position among the leading European states as one united sovereignty and one nationality. Now for the first time she takes her place as a recognised Christian state. Her history was yet to be full of thrilling events and instructive vicissitudes.

Portugal. Portugal was known in classic days as Lusitania, and its present name was taken from Porto Callo, the city in modern times called Oporto. Portugal went through much the same changes as those which Spain experienced by the invasion of the Roman conquerors, and underwent similar changes when the fall of Rome left the country open to the Visigoths and afterwards to the Arabs—indeed, the whole history of Portugal in those earlier centuries is very much like that of Spain. It was after a great defeat of the Arabs that the Portuguese leader Alfonso Henriquez was proclaimed King of Portugal. This was in the twelfth century A.D., and Lisbon,

the principal city, which had been rescued by him from its invaders, was chosen as the place of his coronation, and has since continued to be the capital of Portugal. The Portuguese took their part in the Crusades, and signalised themselves in seamanship, maritime commerce, and exploring expeditions. Prince Henry, the famous navigator, was the son of John I., King of Portugal, and of an English mother, Philippa, daughter of "old John of Gaunt, time-honoured Lancaster," as Shakespeare calls him.

Some Important Discoveries. Henry distinguished himself as a soldier and as a maritime leader in the war against the Moors, and devoted himself during the greater part of his life to the business of maritime exploration. His vessels reached parts of the world never before explored—at least, by European seamen. He had a genius for such discovery; he founded schools for the teaching of navigation, and erected observatories in many ports. He sent exploring expeditions to the gold-mine regions of Guinea, and it was owing to his enterprise that the Madeira Islands were discovered in 1418. For a long time Prince Henry, in his devotion to his main purpose, provided out of his own money the cost of these expeditions, but later, when the great value of his enterprises was more thoroughly understood, the state itself and voluntary private associations supplied the means to enable him to carry on his work more effectually. One of his captains discovered three of the Azores Islands.

Prince Henry died in 1460, and not long after his death the passage to the East Indies by the Cape of Good Hope was discovered by Vasco da Gama, and the Brazils were discovered soon after by Cabral. Thus, Portugal has won for herself a peculiar and distinguished place in the development of civilisation. It was the first European state to devote itself to the business of the exploring navigator with some higher object than that of merely discovering rich foreign territory on which to settle as a conqueror and rule an enslaved population.

Germany. Germany was, from almost her earliest days, divided among several states, although, so far as history can trace the growth of its people, they, though composed of several independent tribes, appear to have sprung from a common ancestry. They had to undergo the invasion of the Romans, and the Romans, in fact, conquered parts of the country, but were compelled to relinquish their conquests before the end of the third century. Later came the invasion of the Huns and other foreign tribes, and these occupied a great extent of the Germanic soil. Charlemagne subdued the Saxons, and became Emperor of the West. He received the Imperial crown from the Pope in 800, and proclaimed that Germany was united with his empire. When the dynasty of Charlemagne became extinct the German populations began to choose sovereigns from various families without regard to the principle of succession. In the reign of Conrad I., King of Germany, during the early part of the tenth century A.D., the German princes appear to have constituted themselves an electoral body, with the right of choosing a sovereign.

We have already seen that in many European states, even where the rule of a sovereign was an institution recognised by the country and sanctified by tradition, the succession according to the strict line of hereditary descent was not accepted as a self-acting condition, and that the nobles and members of the Royal Family often came to an agreement that some one of the reigning household, not the eldest son, should be raised to the throne when a vacancy occurred. In the thirteenth century this principle of electoral choice had become so settled an institution that seven princes were allowed to assume the right of nominating the emperor who was to succeed to the throne. These princes were the King of Bohemia, the rulers of Brandenburg and Saxony, the Elector Palatine, and the Archbishops of Metz, Traves, and Cologne. Other electors were added, and the number was reduced or increased as changes took place until the populations making up the empire became once again divided into separate realms with independent sovereigns.

Founder of Germany's Military System. It is told by M. Duruy in his history that the electoral principle began among German political customs at the very time when French Royalty was becoming hereditary, like the possession of a fief. Under this system Conrad I. was elected ruler of Germany in 911 A.D. A great struggle set in between Conrad, who is described in history as the Frankonian Emperor, and some of the great feudatory states of the German regions. Conrad regarded Saxony as the rival of his own state. He underwent a defeat at the hands of Duke Henry, ruler of Saxony, and on his deathbed, in 918, recommended as his successor his former conqueror, on the ground that he was the man most capable of defending the Empire against the Hungarians. Duke Henry accordingly was elected Emperor, and to him may be ascribed the original foundation of that German military system by which to this day every man above sixteen years of age has to undergo training as a soldier, and has to be ready to serve when called upon. He was succeeded by his son Otho I. in 936. It is not necessary to follow the gradual changes which led to the division of Germany into several distinct empires and kingdoms. We shall tell of the part taken in history by these different states at later periods of our narrative. Germany became divided into Austria, Prussia, Bavaria, Wurtemberg, Saxony, Hanover and other states, each under the rule of an emperor, a king, or an electoral prince.

Hungary. Hungary, which in classic days made part of the regions known as Pannonia and Dacia, was conquered by the Romans in the first century A.D. and held by them for about two centuries, after which it was conquered first by the Goths, then by the Huns, and later by the Lombards. Towards the close of the ninth century a Sythian race named Ungri occupied the country, and from them came the name of Hungary. A

tribe of Magyars, who came originally from the North of Europe, settled in the land, and the chief of the Magyars became the ancestor of a line of Hungarian monarchs. The Hungarians proved to be great invaders of foreign countries, and almost rivalled the Saracens in the extent and daring of their expeditions. For a long time Hungary acted as the chief defence of Christian Europe against the Turks, and later became a part of the political system of Germany.

Union of Denmark and Norway. The three northern kingdoms of Denmark, Sweden and Norway were in early days known by the name of Scandinavia. The Scandinavians were ever active in adventurous explorations, invasions, and conquests, and we have already recorded many illustrations of the spirit which animated them—more especially the Danes—and made them the terror of many neighbouring peoples and even of peoples far remote. In 1397 A.D., under the reign of a famous northern princess, Margaret the Great, daughter of the Danish sovereign, Waldemar III., the agreement known as the Union of Calmar was made between the three northern kingdoms. The terms of this agreement were that the three kingdoms should form a permanent union, while each was to retain its own domestic constitution, its own laws and customs and its own legislative assembly. This union did not last for much longer than half a century, when Sweden withdrew from it and set up as an independent state with a sovereign of its own. Denmark and Norway still remained united, and their union was to endure for yet a long time to come.

The Story of Russia. Russia was the latest of the great European states in emerging from the dusk of history into a position of recognised and settled nationality. The adventurous Northmen, sailing in search of fertile regions and wealth, had made their way into Greenland and Labrador, and had descended upon what was afterwards known as American soil some centuries before the birth of Columbus. The Varangian tribes, under the leadership of their famous chief Rurik, made a settlement at Novgorod, of which region Rurik became the master. Rurik was, according to all the historical evidence, the first to establish a regular state and a settled government in that region. He founded his rule at so comparatively recent a date as 862 A.D. The descendants of Rurik governed the country, not without many difficulties and struggles against invading races, down to the end of the sixteenth century. Among the invasions were those of Tartars and of Danes; Moscow, which had been made the capital of the new state, was burnt down during one of these Tartar wars.

In the fifteenth century Ivan III., a man of great capacity and power, both as military leader and despotic ruler, after defeating the Prince of Moscow and conquering the colonies of Novgorod, founded the Russian monarchy, which has endured down to modern times, and has a history as remarkable for events and for the peculiarities of its developing civilisation as that of any other of the great European states. The Russian Empire, as modern times have known it, had its beginning about the period which we have already reached in England's history. Poland, part of the ancient Sarmatia, had been an independent duchy since about 840, had then been formed into a kingdom, and was later destined to have its fortunes mingled with those of Russia.

The Netherlands. The kingdom of Holland, making up the principal part of the Northern Netherlands, was inhabited by the Batavians in the time of Julius Cæsar, and acquired the dignity of entering into a league with the great conqueror. The principal part of the territory of Holland was made up of soil actually reclaimed from the sea and defended against the recurring ravages of the waves by a vast fortification of dykes. For some centuries it was ruled by counts, who held their position under the overruling sway of the sovereigns of different states at different times.

The country which we now know as Belgium covers the southern portion of the Netherlands. It was occupied at the opening of its history by the tribe called the Belgæ, from whom it takes its name, and was conquered by Julius Cæsar at the same time that he effected the conquest of the northern region, Holland. Belgium became part of France about the year 843 A.D., and was governed by counts who were subject to the French monarchs. In 1385, it came under the rule of Burgundy, then of Austria, and later of Spain. Up to the time which we have reached in this course it had not declared its independence.

Greece. Greece had gone through many changes of fortune since she had sunk down to be a Roman province. She had been invaded by Alaric in 395 A.D., invaded and occupied by the Normans, and was soon to be invaded by the Turks, under whose subjection she was destined to remain until a much later period of the world's history.

We have now followed the development of the European states down to the period we have reached in our account of the progress of England.

Continued

MARVELS OF SIGHT

Optical Instruments. Principles of the Telescope, Microscope, Magic Lantern, Cinematograph, and Camera. The Marvels of the Eye

Continued from page 2903

By Dr. C. W. SALEEBY

THE great advantage of Galileo's telescope was—and is, for the user of opera glasses—that one obtains an erect image, though only two lenses are used. The parallel pencil of light coming through the object glass, which is convex, is received by the concave eyepiece before it reaches its focus, and since the focuses of the two glasses coincide, the rays emerge parallel. Galileo went rapidly on from strength to strength. In a few days he made third and fourth telescopes, the latter making the moon "appear about twenty times nearer, and four hundred times larger than when seen by the unaided eye." He soon found that he had to fix his telescope on a support, in order to obviate shaking. He ground his own lenses.

How Galileo Read the Stars. It was with his fifth telescope, made in January, 1610, and showing objects more than thirty times nearer, that he not merely continued his study of the moon, but discovered four of the seven moons of Jupiter, several fixed stars, and the starry character of the Milky Way. He also made the discovery that, whereas the planets have discs, the stars are mere points. He found 40 stars in the Pleiades (where photography has now shown tens of thousands), and 80 instead of seven in Orion. The broken object glass of this celebrated telescope, the most epoch-making scientific instrument in history, is now preserved in the Tribuna di Galileo, in Florence. In the first half of the year 1610, Galileo made more than a hundred telescopes, which he distributed amongst interested friends and princes. About the middle of that year he discovered the rings of Saturn, though he did not understand their nature, and before long he added the remarkable discovery of the phases of Venus, besides the discovery of the spots upon the sun. Of the former discovery, he says: "Venus rivals the appearances of the moon; for Venus being now arrived at that part of her orbit in which she is between the earth and the sun, and with only a part of her enlightened surface turned towards us, the telescope shows her in a crescent form, like the moon in a similar position."

An Invention and a Revolution. We have thought it worth while briefly to summarise the immediate results of the invention of the telescope, not merely because they illustrate the diligence of Galileo, but because they show the extraordinary consequences which may ensue to science by the invention of a new instrument—in this case nothing more than a concave lens and a convex lens fixed opposite one another in a tube. The most amazing fact of all, perhaps, is that Galileo never got beyond a telescope magnifying a little more than a thousand times, yet his results sufficed to revolutionise the most magnificent of the sciences, and to alter for all subsequent time man's conception of the place of his home in the universe.

As we have hinted, Galilean telescopes are now used only in opera glasses. The ordinary astronomical telescope depends for its understanding merely upon a knowledge of the properties of convex lenses; the concave lens is not employed at all. In describing it, we cannot do better than quote part of the description given by Professor Tait: "The object glass furnishes an inverted but real image of a distant body *within our reach*. We can therefore place the eyepiece (just like a simple microscope) so as to form a virtual magnified image of this real image, treated as an object. It is still, of course, inverted." This inversion of the image, in the case of an instrument used for looking at the heavenly bodies, is, as a rule, of practically no consequence. The distance between the two lenses in the ordinary astronomical telescope is the sum of their focal lengths. In the Galilean telescope it is the difference of their focal lengths.

Magnifying Power of a Telescope. The considerable advance in the use of the telescope, which this instrument represents, is largely due to another astronomer, Kepler, who became possessed of one of Galileo's instruments, and then designed a telescope consisting of two convex lenses—the rays converged by the first of which are allowed, as we have seen, to come to a focus before they reach the eyeglass.

We cannot go at length into the manner in which the following statement is to be proved, but must simply state it. The magnifying power of a telescope may be estimated by the ratio of the focal length of the object glass to the focal length of the eyepiece. It is of interest to note the rough fashion in which the pioneer estimated the power of his telescopes. It illustrates the empirical fashion of arriving at a fact—that is to say, the experimental or *à posteriori* fashion [see LOGIC], as contrasted with the *à priori* or deductive fashion in which the magnifying power of a telescope can now be estimated—in the manner stated—before it is put into use at all. Galileo's method was as follows (quoted from Fahie):

"Place," he says, "upon a wall, at a certain distance, two unequal discs, one of which you will observe with the telescope and the other with the naked eye. If the disc seen through the telescope appear equal to the other, the magnifying power of the instrument is in the proportion of the two discs. If they do not appear equal, the 'other' disc must be enlarged or diminished until they do, and then the magnifying power

will be as before, in the proportion of the discs."

We have already made the acquaintance of the simple microscope—which is indeed simple; and, fortunately, our study of the astronomical telescope suffices for the understanding of the principle of the compound microscope which, in its simplest form, is one and the same instrument. Says Professor Tait: "the only difference is that the object, being at hand, can be placed near to the object glass (still, however, beyond its principal focus), so that the real image formed is already considerably larger than the object, and is then still further magnified by the eyeglass."

The Defects of the Telescope. Of course the reader will not imagine that the telescope and microscope as used to-day are such simple affairs as this, but here, at any rate, we describe their principles. Such simple instruments have certain very decided defects, and in order to obviate these further complications are introduced. Let us see what these defects are.

When we were discussing spherical mirrors we made the acquaintance of spherical aberration. We saw that incident rays, somewhat remote from the pole of the mirror, are not reflected so as to pass through the principal focus, but only so as to pass near it. Similarly also in lenses, the rays which strike them near the edge are not brought properly to the same focus as those which strike the lens near its centre. Hence the image will be blurred, and something has to be done in order to counteract this defect. In the case of mirrors we saw that the difficulty was got over by substituting for a mirror the section of which is an arc of a circle, a parabolic mirror, the section of which is that curve known as a *parabola*. Similarly, we may alter the curvature of a lens, but more commonly we employ combinations of lenses which compensate for each other's defects. Or, again, we may adopt, as is very often done, the simplest possible device, which is to use a circular screen or diaphragm that simply cuts off all the light falling near the edge of the lens, while permitting the light which falls upon its more central part to pass through. The use of a diaphragm for this purpose is of very special interest, since, as we shall afterwards see, every one of us employs this means in his own eye when looking at a near object. Spherical aberration, then, is one of the difficulties which the modern optical instrument has to remedy.

The Case a Single Lens. But there is yet another difficulty, which is called *chromatic aberration*. Remember that the light which is commonly employed in the use of the telescope or microscope is mixed light, consisting of rays of a number of different wave lengths. The difficulty that arises has already been alluded to in a paragraph in a previous section, called the *correction of dispersion*. As we have seen, Newton concluded from his experiments that the amount of dispersion is, for all substances, proportional to that of the refraction, so that to annul the dispersion by any system of prisms would be also to annul the refraction.

Let us now consider the case of a single lens. In any given lens the refractive index varies according to the colour or wave length of the light. Now the focal length of a lens entirely depends upon its refractive index, and hence, though we have talked of the focal length of a lens as if it were an invariable quantity, the actual fact is that *it is a different quantity for every wave length of the light that falls upon it.* One and the same lens has different focal lengths for each constituent of the mixed or white light that may fall upon it. The rays at the violet end of the spectrum are more refracted than those at the other end—in other words, they are brought to a focus first, while the red rays are brought to a focus last. Hence it is that at different distances one gets different rings of colour round the image of any object looked at. In any kind of delicate work this is a very serious defect, and this it is that we mean by chromatic aberration—a necessary defect of all single lenses.

Newton believed that dispersion and refraction are proportional, and therefore that no combination of lenses could ever remedy chromatic aberration without also doing away with the refraction and making them useless. But the mistakes of a great man are far more profitable than the correct opinions of little men. The consequence for Newton was merely that he set to work and invented another kind of telescope altogether.

Newton's Telescope. We shall be treating the subject in the proper chronological order if we consider this new kind of telescope before we go on to show how, after Newton's death, there was discovered a means of obviating chromatic aberration in the manner which he had erroneously pronounced to be impossible.

Newton knew that, whereas light of various colours is variously refracted, it is not variously reflected. If a mirror be used we do not therefore have the difficulty of chromatic aberration which occurs in the case of a lens. (This is why we had occasion to discuss spherical aberration under mirrors but not chromatic aberration.) When white light is reflected by a mirror it remains white, without any coloured rings. Therefore, Newton employed a curved mirror made of highly-burnished metal, and brought his light to a focus by it instead of by a lens. The difficulty arises, however, that if one is to make any observations in such a case, one would have to stand in one's own light. Therefore, a plane mirror has to be used, and placed at right angles to the axis of the curved mirror, so that it reflects at right angles the light which has already been reflected from the curved mirror. There is thus obtained an image, just as by the objective of an ordinary telescope, and this image is looked at and magnified by an eyepiece, just as in the previous case.

The Newtonian telescope has been modified by many other people, notably by the great astronomer Herschell. The most famous of all reflecting telescopes is built on Herschell's plan and was made for Lord Rosse, the reflecting mirror, or *speculum*, being 6 ft. across. It was with this famous reflector that Lord Rosse made

the epoch-making discovery of the spiral nebulæ. Reflecting telescopes are, however, less used than refractors at the present time. The interesting points for the student to remember are the fact that chromatic aberration occurs with lenses but not with mirrors, Newton's belief that no combination of lenses could correct chromatic aberration, and Newton's consequent invention of the telescope which goes by his name.

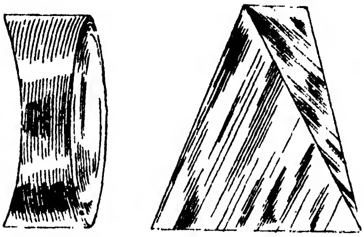
The reader will hardly need telling that the term "Achromatism" is derived from two Greek words meaning *not* and *colour*. Now, Newton notwithstanding, it is possible to correct dispersion, while still allowing some refraction to remain, by means of prisms made of different angles. For instance, the dispersion caused by a comparatively wide prism of glass may be corrected by a much narrower prism containing bisulphide of carbon, while the refraction is not entirely disposed of. Similarly, glass will correct the dispersion of water (the prism of the latter being the wider) though some refraction still remains. It has been supposed that Newton's failure to get this result from practically the very same experiment was due to his use, in his water prisms, of lead, which increases the dispersion of water.

Discovery of the Achromatic Lens. The famous name in the history of this subject is that of Dollond, who performed Newton's experiment over again but obtained a different result. Though Dollond was born in Spitalfields, he was really the son of a Frenchman. He was quite an elderly man before he turned to the subject of optics, but he soon gained great fame. He discovered that, since flint glass causes a greater dispersion, in proportion to its refractive power, than crown glass, achromatic or colourless magnified images can be obtained by using a combination of these two materials—a bi-concave lens of flint glass with a bi-convex lens of crown glass. Each of these had a very considerable aberration, but, by "trial and error," he was enabled to adjust them so that their aberrations were equal and, since their refractions were opposite, the two aberrations neutralised one another.

The explanation of the achromatic lens of Dollond may be otherwise stated. Since flint glass has more dispersive power than crown glass, a weaker flint glass lens will cause as much dispersion as a stronger crown glass lens. The two lenses neutralise one another on the score of dispersion, but the balance of strength on the part of the crown glass lens remains. Hence, the result is white light, which converges as if it had come from a single convex lens equal in strength to the actual convex lens of crown glass *minus* the actual concave lens of flint glass. Such achromatic systems of lenses are always, nowadays, employed in any but the cheapest optical instruments.

Similarly, of course, we can obtain achromatic prisms. These are made of flint and crown glass, similarly combined. A narrow prism of flint glass corrects the dispersion of a much wider prism of crown glass, but, though lessening its refraction, does not altogether dispose of it. Such a combination, therefore, is equivalent to a single prism, equal to the difference between the two actual prisms, but produces an achromatic or colourless result. The accompanying diagram shows the achromatic lens and the achromatic prism.

The Magic Lantern. We must make a brief reference to a few other optical instruments before we pass to the study of the eye—the oldest and incomparably the most wonderful of them



all. There is, for instance, the *magic lantern*, which is of such value in a thousand ways, and which, as we shall see, has lately been adapted to a new purpose. Any reader may examine for himself a magic lantern. He will find that it essentially consists of two lenses, one of which is a relatively small convex lens placed in front of the slide so as to form a large inverted image of it, while the other lens, also convex, is placed between the slide and the source of light in such a fashion that the light is made to converge somewhat and so illuminate the slide as brightly as possible. After the rays of light have passed through the small convex lens at the front of the lantern, they are allowed to fall upon a screen; the further away the screen, the greater the magnification. But, on the other hand the intensity of the illumination is varying all the time inversely as the square of the distance. This is the reason why one can never obtain too powerful light for this purpose.

The Principle of the Cinematograph. It is a great pity that the name of this new invention is so commonly spelt with a "c," for the Greek letter is a "k," and the word is derived from *kinema*, movement. As everyone knows, this is simply a magic lantern in which a series of slides are rapidly passed through the instrument, these slides having been taken from photographs taken at a similar rate. The success of this instrument depends upon a property of the eye. It is known that the retina, or curtain at the back of the eye, retains the impressions formed upon it for about one-fortieth part of a second after the stimulus has ceased to act. Hence, if the cinematograph is worked rapidly enough, one is enabled to obtain a continuous impression. This instrument has been found of very great use in the study of various movements, such as the flight of birds and the action of horses, greyhounds, etc. It has also been found of value for teaching purposes, and has been employed by surgeons, sometimes for the purpose of demonstrating methods to a class and sometimes

for the improvement of their own methods. An operation can be performed and photographed continuously. Subsequently the surgeon can study the reproduction of the operation on a screen, and observe the points at which time could have been saved or other improvements made.

Cameras. In the ordinary camera one employs a lens or system of lenses which are, in effect, convex and which similarly form inverted images, as in the case of the magic lantern. Further, there is another kind of optical instrument, which is usually employed in a dark room, and which therefore goes by the Italian name for such a room—*camera obscura.* Here light is reflected from a mirror or a prism, through a right angle, this being placed in the roof of a room ; on its downward path the light passes through a converging lens, and is focussed on a white table or a table covered with white paper. If the mirror in the roof can be rotated upon a vertical axis, it will admit light from any part of the surrounding country or town. If the reader has not seen this toy in action, he should make a point of doing so when possible. Like the cinematograph, it gives, of course, a living picture, but it is the perfect living picture which our own eyes directly afford us, free from all jerks, vibrations, and other defects.

Our Wonderful Eyes. Merely to call the eye the most wonderful of optical instruments is not to suggest in any adequate degree at all its importance. Of the various senses which we possess for the appreciation of forms of energy around us, none does more than merely acquaint us with a small fraction of the particular mode of energy with which it is concerned. All our senses put together merely succeed in giving us knowledge of small fragments of the possibilities. Thus, of that great ethereal keyboard which we have already described, the eye acquaints us with rather less than a mere octave. Yet the significance of this octave is absolutely immeasurable. It cannot be estimated by the effect upon the individual if he be blind to it, though that is serious enough. It can only be suggested by the attempt to conceive the history and the conditions of human life if the *race* were blind to this octave, as it is blind to the numberless octaves above and below it. Especially is it worth noting, as Lady Welby has pointed out, that man's knowledge of the stellar universe, his knowledge, indeed, of all objects outside his own planet, with the single exception of the sun (which we also know by the sense of heat) depends upon the eye.

It is of the utmost interest, therefore, and of the utmost philosophical value, to have in our minds an outline, however brief, of the history of the eye. If we study the skin of the frog, for example, we find in it a certain number of cells which contain a dark pigment and have a very peculiar character. These cells are *stellate*—that is to say, they have a shape which somewhat resembles the conventional representation of a star. We further find that these remarkable cells are capable of responding, in a striking fashion, to light. But their significance, and their future in the history of evolution, are best to be described in the language of the famous address delivered to the British Association, at Belfast, in 1874, by the president of that year, Prof. Tyndall, one of the most distinguished physicists of last century.

The History of the Eye. "The action of light, in the first instance (says Tyndall), appears to be a mere disturbance of the chemical processes in the animal organism, similar to that which occurs in the leaves of plants. By degrees, the action becomes localised in a few pigment cells, more sensitive to light than the surrounding tissue. The eye is here incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed as the interception of the light is, in almost all cases, by the contact of the closely adjacent opaque body, sight in this condition becomes a kind of 'anticipatory touch.' The adjustment continues ; a slight bulging out of the epidermis over the pigment granules supervenes. A lens is incipient, and, through the operation of infinite adjustments, at length reaches the perfection that it displays in the hawk and eagle. So of the other senses ; they are special differentiations of a tissue which was originally vaguely sensitive all over."

As these words indicate, the eyes originally develop from the skin, the basis of all the senses "being that simple tactual sense which the sage Democritus recognised 2,300 years ago, as their common progenitor." One other note we may make, by way of reminding the student of biology of a fact with which he is doubtless already acquainted. It is that, whereas in the animals called invertebrates—the backboneless animals—the whole of the eye is developed, in the history of the individual, from the skin, and thereafter is connected with the brain by means of the optic nerve, the eye of the vertebrates is distinguished in that its essential parts, though not the less important parts in the front of the eyeball, are developed in a direct outgrowth from the brain itself, this outgrowth travelling forwards to the appointed spot on the skin where a depression begins to form to meet it.

The Parts of the Eye. If we consider the eye, as we may in the first place, from the optical point of view, it bears a very striking resemblance to an ordinary photographic camera. The eyelid evidently corresponds to the cap of the camera. The lens or lenses of the camera are represented by the various lenses or refractive media of the eye. Of these there are several, though one of them is commonly known as *the* lens. In front of this lens there is a hole, through which we look when we gaze at another person's eye, and since all is dark beyond, this hole looks black ; we call it the *pupil.* The hole, or pupil, is bounded by a diaphragm, which is made of muscular tissue, has pigmented cells on it, and is known as the *iris.* The contraction and relaxation of different parts of the iris determine the amount of light that is admitted

through the pupil to the back of the eye. Furthermore, when the pupil is made small, light is prevented from passing through the outermost portion of the lens, and thus spherical aberration is prevented. Marked chromatic aberration, we may note, would occur if there were only one lens, but the several refractive media found in the eye are of different kinds, and are combined so as to form a more or less achromatic lens. We have already noted that one observer, after Newton but before Dollond, drew the proper conclusion from this fact.

Lastly, the eye has a screen or sensitive plate which corresponds to the sensitive plate of the camera. This screen or curtain we call the *retina*. It is, perhaps, the most complicated nervous structure known, having, as the basis of its architecture, no less than ten distinct layers of cells of various shapes and functions, most of which are differentiated nervous cells. To the student of the microscopic appearances of the retina there is almost some humour in describing this incredibly complicated nervous apparatus as a screen or curtain, but, from the point of view of optics, that is all it is.

The Shape of the Eye. In general, the eye is approximately spherical, but there is a conspicuous exception to this statement. A section through the eye from front to back will show that the greater part of its contour is almost circular. This part is what we usually call the white of the eye, and from its hardness it is described by a Greek term indicating that property—the *sclerotic*. But, at the very front part of the eye, the sclerotic becomes continuous with a part which is much more curved or "bulgy," and this part is also distinguished by being transparent. It is of a somewhat horny appearance, and is therefore known as the *cornea*. Its outer boundary nicely coincides with the outer boundary of the iris, and when looking at another person's eye it is through the transparent cornea that we see the iris and the pupil. We may note that, in order to be transparent, it is necessary that the cornea shall contain no blood-vessels. The cornea is the first of the refractive media of the eye. We may note in passing that the cap or eyelid of the eye is not really opaque. It is semi-transparent, but it contains blood-vessels with red blood, and the consequence is, as we shall afterwards come to see, that when we shut the eyes in anything like a bright light we are conscious of a red sensation—red being the only component of white light which is allowed to pass through the eyelid.

The Chambers of the Eye. The eye, as a whole, might be called a dark chamber, but when we come to look at it more closely, we find that it consists of two chambers—an anterior and a posterior. The anterior chamber of the eye is the space which lies between the cornea and the lens. It is filled with a perfectly clear and transparent fluid which is known as the *aqueous humour*. As its name implies, this is a watery fluid, and its refractive index is very nearly the same as that of water. We must not leave our business here so far as to discuss the extremely interesting fashion in which this fluid is produced and drained away, nor the consequences of any interference with its circulation.

The very much larger space which exists between the lens and the back of the eye, constituting practically the whole of the interior of the eyeball, is known as the posterior chamber. It is filled with a substance which is known as the *vitreous humour*, literally, the *glassy* humour. This is commonly described in the textbooks of physics as a fluid, but it is really composed of a very large number of thin, transparent, concentric membranes which are doubtless very moist but cannot properly be described as fluid. The structure is soft enough, however, to permit of the occasional passage of wandering white blood cells through it. Usually, however, we do not notice these cells, but if we have spent a foolish evening or are otherwise out of sorts, the eye is apt to become unduly sensitive and to take cognisance of these little wanderers which it usually ignores. At such times, we say that we have "spots before our eyes," and that is how these spots come about. The vitreous humour has a refractive index which, like that of the aqueous humour, differs only very slightly from the refractive index of water. If the reader cannot, on the spot, define *refractive index*, he may be counselled not to rest content with the well-sounding phrase, but to turn back and find out what it means.

The Iris. Let us now pay a little more attention to the admirable diaphragm of the eye, which we call the *iris*—which has been imitated, by the way, in the making of the best diaphragms for various optical instruments such as the microscope, giving us what every one knows as the *iris diaphragm*. The great function of the iris is to determine the size of the pupil. It consists of two distinct sets of fibres. The greater part of its structure consists of circular fibres, and when these contract, the pupil becomes smaller. Outside them are arranged bundles of radiating fibres, and when they contract the pupil becomes larger. These two sets of fibres are controlled by two entirely distinct sets of nerves, and though the size of the pupil at any moment depends upon the balance between the action of the two sets, they are entirely independent of each other, and are quite differently affected by drugs and various other influences. The movements of the iris are, in general, reflex, and depend upon the brightness and the direction of the rays of light which enter the eye. These rays affect the retina at the back of the eye, and thus, by a nervous apparatus which will be familiar to the student of the course on Psychology, are able to influence the iris. Light entering the eye causes the circular fibres of the iris to contract, and the pupil to become smaller. If the light diminishes, the pupil will become larger. The pupil also contracts as a result of the stimulation of the circular fibres of the iris, when the eye is accommodated for near vision, a process which we shall afterwards explain. This prevents spherical aberration, as we have seen, but incidentally

it of course reduces the amount of light entering the eye. In normal vision this does not matter, but when the eye is long-sighted and is undergoing the change which we shall afterwards study, whereby specially vigorous accommodation is needed, a consequence of the contraction of the pupil accompanying the accomodation is that the patient has considerable difficulty in reading in a dim light. This is the first and most characteristic symptom of the change in the eye that begins to occur usually about the fiftieth year.

The Lens of the Eye. The lens of the eye, or, to give it its full name, the *crystalline lens*, is a transparent bi-convex structure, the convexity being somewhat greater on the posterior surface. It is exactly what its name suggests. When the student first sees a lens by itself, he is usually amazed—it has so entirely the look of a thing manufactured by an artificer. It is enclosed in a thin, tough capsule or covering, but, in health, is not attached to it. The lens itself is not structureless, but consists of concentric layers of fibres, each of which is a modified form of a cell from the outer skin—from which it is derived. The fibres have tiny little notches in their sides and fit into one another. They contain a particular kind of proteid or albuminous substance which, from its physical properties, is called *crystallin*. Space fails for a further discussion here of the lens, but no study of it can be too detailed, since the lens is unfortunately liable to undergo various kinds of changes which render it opaque, leading to the disease known as *cataract*.

Before birth, the lens is almost spherical, and has a reddish tint, due to the presence of blood-vessels in its capsule. The normal adult lens is somewhat flatter and colourless. After about the fiftieth year the lens becomes somewhat amber coloured, its softness, its elasticity, and its convexity all diminish. Each of these statements is of the greatest practical importance.

Attachments of the Lens. Lastly, before considering the function and behaviour of the lens under different optical conditions, we must note that there is attached to the capsule of the lens a powerful fibrous structure which is in its turn attached to a muscle called the *ciliary muscle*, in such a fashion that the behaviour of the muscle can affect the pressure to which the lens is subjected, and thus modify its degree of convexity. But, for this process to occur, it is evident that the lens must possess, in a perfect degree, that physical property which we call elasticity. The technical name for the important structure in which the lens is thus, so to speak, slung, is the *suspensory ligament*.

The Retina. We have already described in sufficient detail for our present purpose all the parts of the eye except the essential part—the *retina* itself. Its structure, as we have already seen, is infinitely complicated, and we must return to it when we attempt to outline the physical or physico-chemical theory of vision. Meanwhile, however, we are concerned merely with the optics of vision, and for our present purpose it is necessary to know only two facts about the retina.

The first is that there is a particular part of the retina which is known as the yellow spot or *macula lutea*. Its peculiar characteristic is that, in consequence of its microscopic structure, it is the most sensitive and discriminative part of the retina. Consequently, the optical problem for all of the front part of the eye is to focus rays of light from external objects upon the yellow spot.

The Blind Spot in the Eye. Furthermore, there is another part of the retina which is precisely opposite in its properties, being known as the *blind spot*. Rays of light falling upon it are not seen at all. This is the point at which the optic nerve enters the eye, and is entirely destitute of any visual cells. The blind spot lies at about one-tenth of an inch inside the yellow spot; its existence can easily be proved. Take a sheet of paper and draw upon it, side by side, but with about 3 in. between them, a cross (x) to the left and a dot (·) to the right; close the left eye, and look straight at the cross with the right. At the same time one is able to see the dot. But if the distance between the paper and the eye be varied, a point will be reached at which the dot absolutely disappears—provided, of course, that one keeps the eye steadily fixed upon the cross. At this particular point the rays of light from the dot have been focussed upon the blind spot of the retina, where they signify nothing. This fact has been already referred to, and the experiment illustrated in the course on Physiology [page 2403]. Practically, the existence of the blind spot does not matter at all, since it is with the yellow spot that we do all the vision which, so to speak, we care about. The rest of the retina has its own value, but the attention [see PSYCHOLOGY] is concerned merely with what falls on the yellow spot.

Continued

QUARRY PRACTICE

The Appliances and Processes of Extracting Stone and Minerals by Quarrying. Typical Quarries and their Operation

Continued from page 2850

By D. A. LOUIS

FOR quarrying in hard stone for some purposes—for instance, to furnish road metal, where the rock being broken up somewhat does not matter—a procedure similar to that already described [page 2850] is followed. But where the rock is valuable and has to be in good unshattered blocks, as in the case of marble and building stone, a system of holing and wedging, or of plug and feather, or of sawing is employed in preference to blasting.

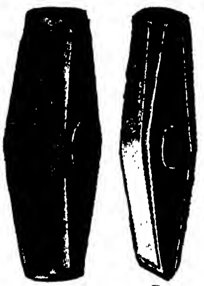
In some cases, where any rents or shattering would be undesirable, the quarryman makes a number of small holes with a pick along a certain length of rock; into these he inserts steel wedges, and after a succession of blows with sledges or heavy hammers the rock is split through by the wedges. Blocks for columns, obelisks, tombstones, etc., are best procured in this way.

Mountsorrel Granite Quarry. This quarry furnishes an excellent example of the best practice in the production of material for road metal, paving setts and kerb stones. It is worked in a great granite boss jutting up through the surrounding Triassic country seven miles to the north-west of the town of Leicester. The site of the quarry is discernible from a distance, the hills in the vicinity giving a special and marked character to the landscape; but some of these hills on closer acquaintance prove to be artificial, or nothing better than spoil heaps. The quarry is of considerable size and is worked in three benches or floors, the lowest called the sinking pit, with a bank or working face 100 ft. high; the second called the gullet, with a 40 ft. bank, and the third, known as the top lift, with 90 ft. of bank. The gullet and top lift are connected by normal gauge railway, branches from which are kept up to the working faces, for which purpose special gangs of platelayers are kept constantly employed.

Fig. **44** is a view of the top lift, the bank, with some fallen rock, the full gauge rail and branches, the settmakers' sheds, and the supplementary narrow gauge rails are all shown. The sinking pit, in which there are six working faces, is not connected to the gullet, but is served by narrow gauge lines converging to a landing commanded by a crane stationed at the gullet level. Trucks of rock are wheeled to the landing, and then the bodies with contents are lifted up and brought to the distributing railway system.

44. TOP LIFT, MOUNTSORREL QUARRY, LEICESTERSHIRE

Winning the Stone. The winning of the stone is done by drilling and blasting, hand drilling being used where machine drilling cannot be employed owing to inaccessibility. The hand drillers work in gangs of three and drill about 7 ft a day; whereas two men work a steam drill and do 20 ft. a day. For the purposes of steam drilling, small portable vertical boilers, mounted on carriages running on the broad gauge railway, working up to 80 lb. pressure, and accompanied by a tool truck and water tank, are brought as near the working places as convenient. The holes are generally put down vertically from the gullet or top lift with steam drills; the holes start about 3½ in. in diameter and diminish to 3 in. at and beyond a depth of 25 ft. The blasting is done gradually. A small charge with light tamping is first employed to enlarge the bottom of the hole, or to do some easing; this is followed by a larger charge well tamped to the top of



45. QUARRY HAMMERS

A and B. Stone hammers
C. Granite hammer or chopper

the hole with granite dust; by this means thousands of tons may be brought down at one blast. Blocks of all sizes and shapes are produced in this manner; the larger blocks are reduced in size by means of drilling and blasting. They then fall into the hands of the *blockers*, or men who prepare the fallen stuff for the settmakers and produce the rough for the mill. They use crowbars and various hammers, the *burster* and *spaller* each weighing 28 lb, and the *chopper* weighing 8 or 9 lb. It is interesting to watch the *blockers* at work and to observe how they know and utilise their knowledge of *the grain* of the stone, a character imperceptible to all but the initiated.

Distribution of the Produce. The produce of the quarrying is distributed to the settmakers, to the mill for road metal, and the useless stuff to the spoil heap. For the last two purposes it is loaded into waggons on the normal gauge railway and taken away in trains by locomotives to its destination. The settmakers work in sheds on the floors of the quarry itself [44], and wheelbarrows suffice to carry the rough material to them. The loaders do this work.

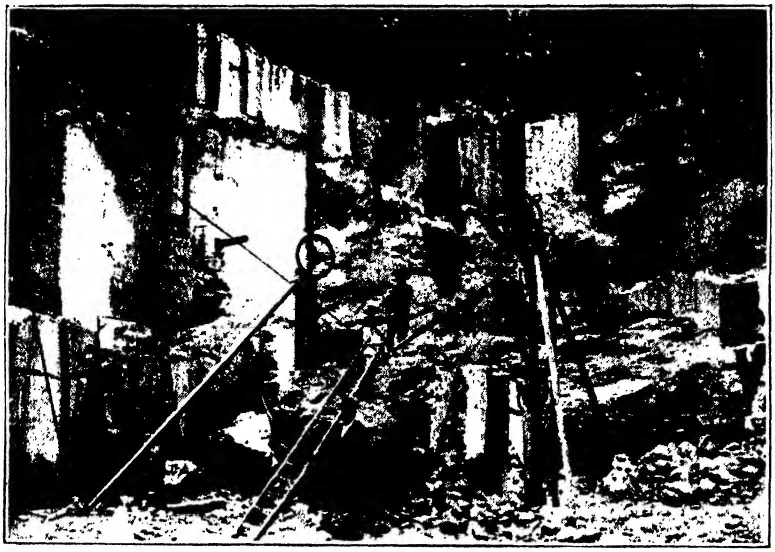
For shaping the setts, smaller *bursters* and *choppers* weighing about 4 lb. are used, and the finished setts are taken to the depot by a special narrow gauge railway. It is noteworthy that 30 tons of hammers are constantly in use, and all these are made on the spot. Various hammers are illustrated in **45**. They

46. SANDSTONE QUARRY

are made with bodies of best Swedish iron, faced at the ends with steel. The iron does not break at the eye as steel is liable to do. The hefts or handles are made by machinery. The road metal mill will be noticed in its proper place in this course.

It will be observed that engines, cranes, pumps, etc., have been introduced in these workings and in some quarries in the vicinity and elsewhere. Henderson's overhead cableways are also in use for transporting the stone.

Freestone Quarries. The Bath stone quarries furnish an example of one of the methods of removing stone without shattering it. These beds of freestone vary from 8 ft. to 24 ft. in thickness, and occur in the Great Oolite [see GEOLOGY]. The first process in removing stone consists in cutting a horizontal groove with the pick to a depth of 5 ft and a length of 20 ft. to 25 ft.; then, by means of a saw, vertical cuts are made from this groove; a piece of stone is wedged out from the centre between the first two vertical cuts. The rest is then simply sawn into blocks, which, when set free, can be detached by wedges and lifted off by cranes and loaded into trucks direct, or roughly dressed and stacked in the quarry. The saws are 6 ft. to



47. HELICOIDAL WIRE AT WORK IN A BELGIAN MARBLE QUARRY

8 ft. long, and 10 in. to 12 in. wide, narrower ones being used at the groove to start with. The heaviest saw weighs 56 lb., and a man can saw 15 sq. ft. in soft rock in an hour. The process is employed in many soft stone or freestone quarries. The top groove is not required when the beds are uncovered.

Harder rocks require the groove to be cut by a machine, and usually a rock drill that can be moved along a bar is used for the purpose, and so a line of holes one beside the other is drilled, and the block of stone can be wedged away when set free by this *channelling*, as it is called.

Fig. **46** is a view in a sandstone quarry and shows the regular mode of working and the pronounced jointing planes.

The Helicoidal Wire. The helicoidal wire, consisting of an endless cord made of three hard wires twisted together, is also used for cutting the necessary grooves in some quarries.

Fig. **48** is a view in Maillon slate quarry in the Pyrenees, taken by Mr. G. J. Williams, H.M. Inspector of Mines, and shows the magnificent cuts made by this system of working. The cord is made to travel by machinery, and is fed continuously with sand and water, the sharp particles of sand gradually cutting a groove. It is kept against the rock by means of guiding pulleys, which are mounted in pits previously sunk at the extremities of the proposed cut. Fig. **47**, also taken by Mr. Williams, shows the helicoidal wire at work cutting up a block of marble in a Belgian quarry. The two upper, but only one of the lower guide pulleys are visible. The lower ones are moved down as the cutting progresses. The water tank is also shown.

48. MAILLON SLATE QUARRY
Showing results of using the helicoidal wire

Special Blasts. Special blasts are sometimes used in stone quarries. When a high cliff face is to be worked, the ordinary method of terrace working would make too much small, and the channelling method would not be applicable; it is then customary to drive a tunnel some 50 or 60 ft. into the face of the

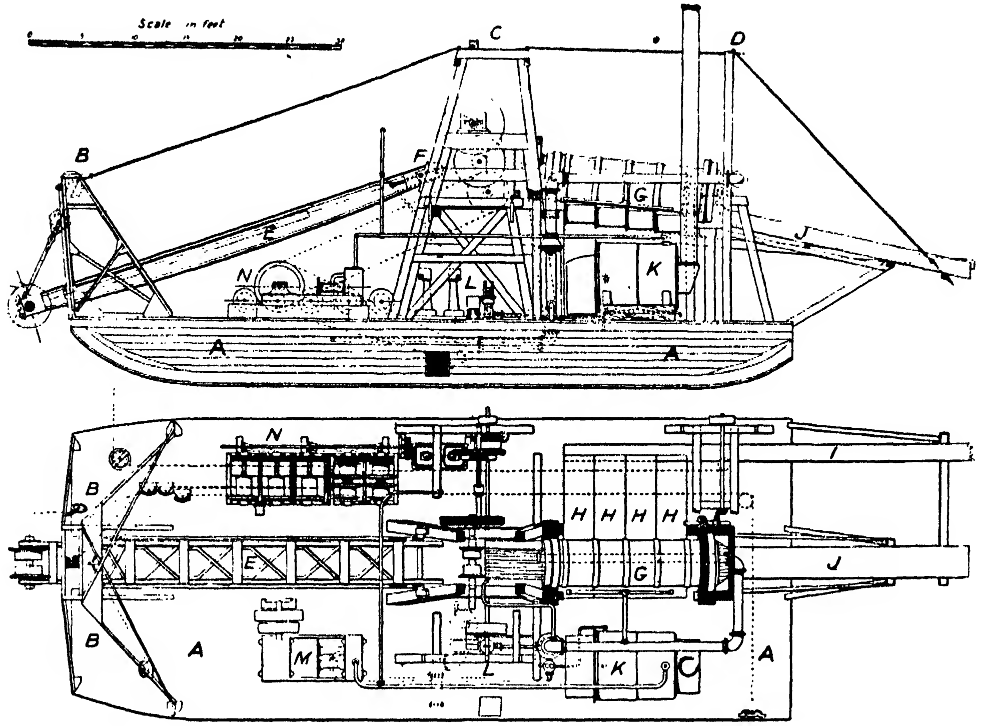
49. HEAVY FALL OF ROCK FROM A SINGLE BLAST

cliff, and at the end to excavate a chamber at right angles. This chamber is charged with a ton or more of an explosive, into which ordinary fuses are inserted; the tunnel is then built up, starting with concrete, following on with loose masonry, brick walls, and earth stopping, so as to provide a stemming or tamping to the charge; then the charge is fired, and it is quite remarkable to see a great mass from the front of the cliff break away and slide down quite steadily. Still more remarkable is the great pile of rock that is thus brought down, some of it in huge, formidable blocks, which are subsequently reduced to convenient sizes. The writer has seen 25,000 tons of stone brought down by one shot in this manner. Fig. **49** illustrates a great fall of this description. The whole mass of broken rock extending behind the party back to the cliff face has been brought down by a single blast.

Subaqueous Deposits. The deposits hitherto considered could be worked without the employment of water beyond that required for domestic purposes and boilers. But during a prospecting expedition it is quite possible that other kinds of useful mineral deposits may be encountered. The river bed, for instance, may have shown signs of mineral wealth. In such a case, if the deposit be imbedded in the mud at the bottom of the river, dredging, as the simplest means, is adopted.

Dredging. The dredger for mineral mining purposes consists of *the float* or *pontoon* for supporting the plant; of *the arrangement for bringing the material up* from the bed of the river, lagoon, alluvial flat, sea-beach, or even sea bottom; of *the washing apparatus* for separating the valuable from the worthless stuff, and of *the appliance for disposing of the waste or tailings.* Of course, *engines* and *winches* are necessary to work the plant and to manœuvre the float. For bringing up the material, *buckets, grabs,* or *suction* appliances are used; for washing the stuff, screens and tables or sluices with riffles or such appliances are used. The whole of the stuff goes to the screens when they are installed, and what passes through is run in a thin stream over special tables; and in any arrangement employed, the light stuff is washed away in one direction, while the valuable matter passes off another way, and is collected. The waste is taken away by means of a conveyor, or otherwise, and is deposited at the rear of the pontoon, so as not to interfere with the undredged deposit.

A bucket dredger is shown in **50** in elevation and plan. A is the pontoon, B, C, D are respectively the ladder frame, the tumbler frame, and the sluice frame. E is the ladder for carrying the buckets. The ladder is hung from F and is let down or pulled up from B. G is the screen, H the tables, I and J sluices leading astern. K, L, M are the boiler, pump, and engine, N are the winches for executing the various manipulations by means of ropes indicated by dotted lines on the plan.

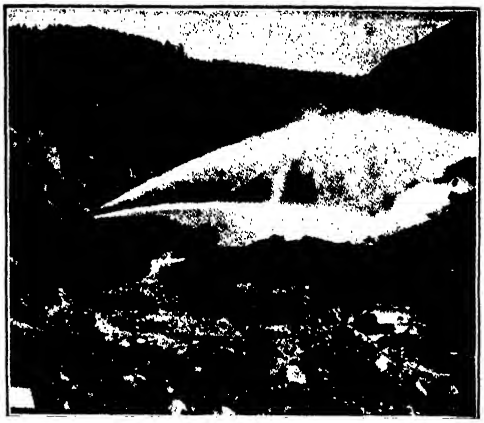


By permission of] **50.** DREDGER WITH SCREEN [Institution of Mining and Metallurgy

The dredger floats in the water above the ground that is to be worked, and is caused to move sideways so as to pick up the whole width of the deposit, and, after completing a cut, is advanced sufficiently to make a new one. Sometimes, instead of dredging, the course of a river is diverted and the deposit left accessible in this way worked by streaming or otherwise. A river is generally diverted by means of dams, but **51** shows a means adopted for disposing of a river while extensive operations were conducted in its proper bed.

Streaming and Ground Sluicing. River and other sands containing valuable material are frequently treated by working them with water and stirring up well at the upper end of long inclined troughs, in which, moreover, a stream of water is kept flowing, the lighter particles of waste material are carried away, while the heavier particles of valuable material settle, and wood or stone riffles are fixed in the bottom of the trough to aid the settlement of these particles. In the case of gold, mercury is put in as well, to retain the precious metal. Gems, also platinum and tin, are separated from the sands in which they occur by washing with water in the trough or some other of the simple appliances which will be referred to later on. Operations of this character are known as *alluvial washings*, *beach washings*, or *streaming*, and they require a good and constant flow of water at a low head.

Hydraulic Mining. When, however, the sand or gravel deposits or placers occur below considerable loose overburden where shafts and galleries would be costly to make and maintain and dangerous to work in, the method of mining known as *hydraulicing* is adopted. In this method of mining jets of water of great force and size are projected from adjustable nozzles [52] known as *monitors* against the bank of gravels and overburden, as a rule toward the lower portion, and the force of the water disintegrates, loosens and washes away the material—not alone sand and gravel, but even boulders, if present, being dislodged and carried away in the issuing stream. In this way a cavernous opening is cut out at the base of the bank and continues to increase in size until the unsupported overburden can no longer stand, and comes toppling down, bringing with it in its fall trees and everything else that may have been on the surface.



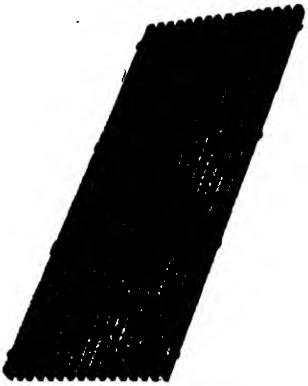
52. JETS PLAYING ON GOLD GRAVEL

The jets of water are then directed on to the fallen mass, which is soon reduced and carried away as a rushing stream of muddy water, sand, gravel, and stones. The quantity of gold present is generally exceedingly small; in fact, as little as a few grains per ton or little over a millionth of the whole mass has been successfully extracted by hydraulic mining.

Saving the Gold. In this instance, too, the precious metal is saved by conducting the stream through inclined troughs fitted with impediments in the bottom, and mercury is added to retain the particles of gold as they sink down through the accompanying and relatively lighter material. The wooden troughs or *sluices* in these cases may extend for a few feet, or even hundreds and thousands of feet, usually commencing at a ditch cut through the ground. Boulders are lifted out of the way by an extemporised crane or any other simple contrivance. Smaller blocks of stone or large pebbles are disposed of by giving the

51. TROUGH STRUCTURE FOR ACCOMMODATING RIVER WHILE CONDUCTING OPERATIONS IN ITS BED

sluice in course of its run a sudden drop and at the same spot changing its direction; a *grizzley* or *inclined grating of bars* [53] set at any desirable distance apart is fixed in a line with the first set of sluices, but stretches across and over the new course. The stream with stones rushes violently over this grating; the stones, however, cannot pass through, and are projected out of the way, while the stream of heavier material follows the new course. From time to time the flow of the stream is arrested, or it is diverted into a parallel line of troughs, so as to be able to continue operations while the material accumulated in the vacated course is taken out and the gold that has accumulated among the riffles duly secured. This is the *clean up*, as it is called, and is also the final stage of the hydraulicing. Banks of any height may be worked by this method, provided water can be had under head enough to be thrown against the bank to be effectual from a sufficient distance to keep the workers out of the way of the falling material. Two essentials for working on the hydraulic system are an ample supply of water at a high pressure at the head of the work, a sufficient fall, and a sufficient area of ground for the sluicing, which possibly also must be extensive enough for the disposal of millions and millions of units of useless matter at the tail end. When once installed this is one of the cheapest and most efficient methods of mining.



53. GRIZZLEY

Hydraulic Elevators. In some cases a want of fall has been overcome by forcing the washings from the bank of gravel up to an elevated reservoir connected with troughs or *sluices*, supported at the higher level on trestles.

If an adequate supply of water with the necessary head can be found in the neighbourhood, so much the better; but only too frequently this is not the case. For instance, in one the writer inspected, a source nine miles away had to be drawn on to obtain both quantity and head of water. The water in such cases has to be brought to the mine with as little loss of head as possible, and it is conveyed in ditches, where they can be used, or in wooden troughs, which may rest on the ground or be supported on trestles, or suspended from the face of cliffs as emergency arises, while even pipes are called into requisition sometimes when crossing valleys.

54. UNDERGROUND SLATE QUARRY, FESTINIOG

Land Dredging. When both head and quantity of water fail, and the placer is also level, it may be worked by means of a dredger, by the system known as *land dredging*. For this purpose a sufficiently large basin is excavated into which water is admitted to form a pond, upon which the dredger is erected and set to work; it will cut away the ground in front, which of course is replaced by the water, while it banks up the waste behind, which in its turn pushes out the water. The pond thus advances with the dredger, and a comparatively small quantity of water suffices for the work. When the conditions for any of these open-air methods fail, then a placer, if rich enough, would be worked by underground methods.

Open-cast and Underground Work. Between open-cast or open-air work and underground work there is no special barrier, and, in fact, it is frequently found expedient to work the same deposit by both methods. Many examples of this occur both in our own and foreign countries; among others, slate deposits in Wales are quarried both in the open air and underground. In fact, **54** is a view, taken by Mr. G. J. Williams, in an underground chamber in Oakeley Slate Quarry, Festiniog. Observe the fine cleavage surface of slate, the lifting tackle, and the tram rails coming round the level. Whenever it becomes expedient, as, for instance, on account of the inconvenience or expense of removing the overburden, or when, as already remarked in another place, a deposit is required more rapidly than the overburden could be removed, underground methods are adopted.

Continued

A STUDY OF ENGLISH FICTION

Continued from page 2787

I. A Brief Introduction to the Earliest Writers of English Prose Fiction, with a Note on the Place of the Novel

By J. A. HAMMERTON

THAT there are in our midst to-day many people to whom the word "novel" is anathema indicates how invincible may become a prejudice that has once sunk deep into the public mind. For generations the novel has been a thing abhorred by a considerable section of the religiously minded, and although a more liberal view of fiction is now, for the most part, held by those of the class that in the past contemned it, there still exists against novel-reading an amount of prejudice which can be maintained only by ignorance of what a novel really is. The double meaning of the word "fiction" may probably have had something to do with the continuance of an antagonism which, originating no doubt when novels were too often stuffed with scandalous "adventures" and preposterous stories wherein lawless passions were at least displayed if not always belauded, has long since ceased to have more than occasional justification. "Fiction," as implying prose writings of fancy and creative imagination, has no manner of relationship with the "fiction" that is synonymous with lying or falsity, and is told "with intent to deceive."

"Fiction" and "Truth." Prose fiction, indeed, may be the very essence of truth; in the hands of the master writers it is truth. A historical novel, wherein the actual facts of history may be altered by the romancist to suit his story, may yet give, as a whole, a picture of the time in which its action takes place that is nearer to the life than a history that is accurate in every detail. By sheer mental vision the novelist sees and conveys to us an impression of the truth that is more vivid, more lasting, than the historian with his procession of recorded facts may be able to make it to us. Thus, one could betray no greater ignorance of literature than to suggest that prose fiction was unworthy of serious study on the ground that "mere fiction" can be of no use to anyone. Cut out the romance, the novel, and the short story from English literature, and it would be small comfort to protest that there still remained to us the history, the essay, the poem, and the drama; yes, even though these preserved a Carlyle, a Lamb, a Wordsworth, and a Shakespeare! Our prose fiction must be accounted one of our greatest national treasures, and no matter how contemptible some modern novels may be, they are but unworthy specimens of a magnificent literary form to the standard examples of which we counsel the student and the general reader to give serious consideration.

What is a Novel? The great novel is, in a word, one of the indispensable means of modern culture. Jane Austen's description of the novel as it should be can hardly be improved upon. A novel, according to this charming exponent of one phase of the art of fiction, is a work "in which the greatest powers of the mind are displayed, in which the most thorough knowledge of human nature, the happiest delineation of its varieties, the liveliest varieties of wit and humour, are conveyed to the world in the best chosen words." And did not R. L. Stevenson write: "The most influential books, and the truest in their influence, are works of fiction. They repeat, they rearrange, they clarify the lessons of life; they disengage us from ourselves, they constrain us to the acquaintance of others, and they show us the web of experience, but with a singular change—that monstrous, consuming *ego* of ours being, for the nonce, struck out"?

The Importance of the Novel. When worthy of the name the novel combines the essential qualities of drama and poetry; when perfectly fashioned it is as much a work of art as a statue by Phidias or Praxiteles, or a painting by Raphael or Titian, and it demands and deserves to be judged accordingly. Some of the greatest men have sought relaxation and found inspiration in reading and in writing novels. If time is wasted over works of fiction the blame must attach only to the quality of those that are read, and the carelessness of the reader in his choice. It is too frequently forgotten that novels, as a form of art, must be regarded as we regard dramas and poems. Drama is composed of two main divisions, comedy and tragedy; but each of these divisions has many subdivisions, and the quality of a play is to be judged by its relation to the standard of its particular division. This is the case with the poem and its relation to what we understand by the epic, the narrative, and the lyrical standards, as we have already learned in previous studies. What is true of the play and the poem is true of the novel, with this proviso: that the novel is susceptible to more numerous gradations, a still more intricate classification.

The late Sir Leslie Stephen once defined the artist as one whose main purpose it is to receive impressions of images the reproduction of which may make this world a little better for us all. This description of the artist is absolutely true of the writer of novels who is a novelist in deed as well as in name.

Aids to the Study of Fiction. But here comes the difficulty for the student, at whatever age he may approach the theme, as the field covered is so vast. The phrase "the world of fiction" is no idle figure of speech. The student of fiction needs chart and compass no less than the traveller in an unknown country; without them inevitably he will have

more to regret than mere waste of time. Let him, therefore, begin by consulting carefully some good map of the country he proposes to explore. In other words, let him at the outset of this branch of study secure some sound knowledge of the history of the subject as a whole, so that he may not fall into the error of accepting fiction as mere "reading for an idle hour." To this end he cannot do better than consult the latest edition of the standard history by John Colin Dunlop (d. 1842). The full title of this work, originally published in 1814, is as follows: "The History of Fiction: Being a Critical Account of the Most Celebrated Prose Works of Fiction from the Earliest Greek Romances to the Novels of the Present Age." The title alone suggests the wide scope of the study dealt with. The work was recast by H. Wilson in 1888. For a short study of the subject we know of nothing better than David Masson's brilliant lectures: "British Novelists and their Styles: Being a Critical Sketch of the History of British Prose Fiction" (1859). Another invaluable and more easily procured work is Professor Walter Raleigh's "The English Novel: Being a Short Sketch of Its History from the Earliest Times to the Appearance of 'Waverley.'" B. Tuckerman's "History of Prose Fiction" (1882), Sidney Lanier's "The English Novel and the Principles of its Development" (1883), and W. J. Dawson's "Makers of English Fiction" (1905) are also useful. The student who has mastered these books, or even the first, second, and last-named, will be in a position to make that choice upon which the profitable study of particular periods or writers depends. But much that is of real service will be found also in Jonathan Nield's "Guide to the Best Historical Novels and Tales" (1904), Elizabeth's Lee's able translation of M. Jusserand's "The English Novel in the Time of Shakespeare" (1901), Nassau W. Senior's "Essays on Fiction" (1864), the Hon. A. S. G. Canning's "History in Scott's Novels" (1905), Walter Frewen Lord's "The Mirror of the [Nineteenth] Century" (1906), and Sir Walter Scott's "Essay on Romance."

The Origin of the Novel. It does not fall within the scope of this short study of the beginnings of English fiction to trace the origin of the novel back to the dawn of folk-lore and legend. There is no trait in human nature more universal than the love of story-telling and story-hearing. The first of novelists were undoubtedly the professional story-tellers of the East. The old tales and legends and romances, from which the modern novel has sprung, passed from one generation to another by word of mouth. Their history is akin to that of the Hindu Scriptures. One example may be quoted as evidence of the love of the story and of its utility: the interest awakened in the young by the stories and parables of the Bible. Modern research has discovered novels in the brick libraries of Babylon and in the inscriptions on Egyptian papyri. Professor Flinders Petrie, for instance, in his "Egyptian Tales," has this noteworthy comparison: "It will be noted how the growth of the novel is shadowed out in the varied ground and treatment of the tales (dating from 4000 B.C. to 1000 B.C.). The earliest is purely a collection of marvels or fabulous incidents of the simplest kind. Then we advance to contrasts between town and country, between Egypt and foreign lands. Then personal adventure, and the interest in schemes and successes, becomes the staple material; while only in the later periods does character come in as the groundwork. The same may be seen in English literature—first, the tales of wonders and strange lands, then the novel of adventure, and lastly the novel of character."

Influence of Foreign Writers. In a European sense, as Emerson says, every novel is a debtor to Homer. Indebted to the "Iliad" and the "Odyssey," it is also beholden to Italian influence and example. Though the point is as elusive of settlement as the origin of the English drama, the fact that the word "novel" is derived from an Italian root favours the theory of the descent of this branch of English literature from the intercourse between England and Italy in the fourteenth century. One of the fathers of the novel is certainly GIOVANNI BOCCACCIO (b. 1313; d. 1375), who was known to old English writers as John Bochas, and who was one of the first of the moderns to give to popular tales the graceful garb of prose-fiction. But English commerce with Spain and Portugal in the sixteenth century is a factor in our literature that cannot be overlooked. So with Homer and Boccaccio we must place MIGUEL DE CERVANTES SAAVEDRA (b. 1547; d. 1616) among the potential fathers of English fiction. Nor must we forget the influences of the Norman Trouveurs, of the chivalric legends of Alexander, Charlemagne, and King Arthur, and of the satirical fiction of FRANÇOIS RABELAIS (b. 1483; d. 1553). These points are admirably and lucidly dealt with by Professor Masson, who notes as of especial significance the dates of the following translations into English (we have already drawn attention to the wealth of English translations in our study of English Prose): Part of Boccaccio in 1566, followed by Cintio's "Hundred Tales"; the "Golden Ass" of Apuleius, in 1571; the "Æthiopica" of Heliodorus, in 1587; Mendoza's "Lazarillo de Tórmes," by David Rowland, in 1586; the "Diana" of Montemayor, in 1598; "Don Quixote," first in 1620; and Rabelais, by Urquhart, in 1653. The deduction is that the novel of adventure and gallantry, the pastoral romance, and the picaresque novel (or novel of roguery, of Spanish origin), may have been naturalised in Britain by the beginning of the seventeenth century.

The First Original Novel in English. Meanwhile, England had produced a form of prose fiction which was indigenous. The outstanding examples were the Latin allegories of More ("Utopia," 1516), Barclay ("Argenis," 1621), and Bacon ("New Atlantis," 1627). In 1579–80 appeared "Euphues," the first original prose novel written in English. The

author of this work was JOHN LYLY (b. 1553; d. 1606), of whom as a dramatist we heard on page 679. The story is quite uninteresting to the modern reader; but the style in which it was written suggested a new word, "euphuism," and promoted a form of popular "polite" dialogue the influence of which is traceable in Shakespeare (*cf.* Adriano de Armado in "Love's Labour's Lost," and Malvolio in "Twelfth Night"); Ben Jonson (Puntarvolo in "Every Man out of His Humour"), and Sir Walter Scott (Sir Piercy Shafton, in "The Monastery"). Lyly has been unduly despised and much misrepresented. His importance as one of the first writers of witty prose dialogue in English is the chief fact in regard to him that the student has to bear in mind.

Elizabethan Prose Fiction. Next to Lyly's "Euphues" the posthumous "Arcadia" (1590) of Sir PHILIP SIDNEY (b. 1554; d. 1586) claims attention. Indebted as Sidney was to foreign influence, and particularly to the Italian Sannazaro and the Portuguese Montemayor, both disciples of Boccaccio, his pastoral romance enshrines true passion and has a ring of chivalrous sincerity that is absent from "Euphues." Sidney borrowed, but gave also. French and English writers felt his influence. Shakespeare is one of his debtors, and Professor Raleigh points out that Richardson is "the direct inheritor" of the analytic and sentimental method in romance which Sidney developed. The "Arcadia," as Professor Raleigh observes, "is in some sort a half-way house between the older romances of chivalry and the long-winded 'heroic' romances of the seventeenth century. Action and adventure are already giving way to the description of sentiment, or are remaining merely as a frame on which the diverse-coloured flowers of sentiment may be broidered." The student will find a great deal to interest him in the writings of ROBERT GREENE (b. 1560? d. 1592); THOMAS LODGE (b. 1558? d. 1625), whose "Rosalynde" (1590) inspired "As You Like It"; and THOMAS NASH (b. 1567; d. 1601), whose "Unfortunate Traveller" (1594) is cited as the earliest example of a picaresque romance in English literature, and who is the immediate forerunner of Defoe.

Allegory, Romance and Realism. Of course Chaucer, a contemporary of Boccaccio, was really one of the first of English story-tellers. The "Canterbury Tales" are full of wit, humour, knowledge of life, and generous tolerance; but Chaucer, like the later writers to whom we have been referring, wrote primarily for the Court and the Universities. "The Pilgrim's Progress," written by JOHN BUNYAN (b. 1628; d. 1688), in Bedford gaol, and published in 1678, was addressed to the simple understanding of the "common people." It is the first great popular allegorical narrative in the language, and its history provides a permanent moral for all writers who seek to influence their fellows by the use of the pen. Twenty years after the appearance of "The Pilgrim's Progress," two works by Mrs. APHRA BEHN (b. 1640; d. 1689), "Oroonoko" and "The Fair Jilt," were published posthumously. With these works the novel of contemporary life may be said to have begun. "The Fair Jilt" is of little importance; "Oroonoko" anticipated Rousseau. But heroic and pseudo-chivalric romance had lost its savour. A reaction now set in towards realism. Mrs. MANLEY (b. 1663; d. 1724) and Mrs. HAYWOOD (b. 1693? d. 1756) utilised the story as a vehicle for current scandal.

Prose Fiction of Defoe and Swift. Then came DANIEL DEFOE (b. 1661; d. 1731), one of the greatest realists in English letters. With him the art that conceals the author from the reader, and induces the latter to believe that what he is perusing is a transcript from unquestionable first-hand evidence, attained a standard that has been but seldom if ever excelled by later writers. The world-famous "Life and Strange Surprising Adventures of Robinson Crusoe, of York, Mariner" (1719), is Defoe's finest work; but his "Moll Flanders," "Colonel Jack," and "Roxana" are still read as typical examples of the Newgate Calendar novel at its best. The realism of "Robinson Crusoe" finds a counterpart in "The Travels into Several Remote Nations of the World by Lemuel Gulliver" (1726–1727), of JONATHAN SWIFT (b. 1667; d. 1747). In neither work, it will be observed, is any great appeal made to the emotions. The student should also take special notice of the association of Defoe and Swift with the pamphlet and the newspaper. It is an interesting speculation whether the newspaper, foster-parent of the novel as it has proved, may not one day itself supersede the novel. The journalistic work of Defoe and Swift has been already referred to; but in passing to the first of the great English novelists another fact worth mention is the influence of such publications as the "Tatler" (1709–1711) and the "Spectator" (1711–1712) on the formation of a public taste which it was the destiny of Richardson, Fielding, Sterne, Smollett, and Goldsmith to satisfy. The rise of the novel as distinct from the romance and the allegory has pursued lines that are almost parallel with the progress of the woman's movement. This point is mentioned as suggesting a promising line of study.

Continued

Group 16
HOUSEKEEPING
18
LAUNDRY WORK
continued from page 2912

MANAGEMENT OF A LAUNDRY

Laundry Machinery and its Operation. Expense and Profits of a Steam Laundry. Laundry Economy

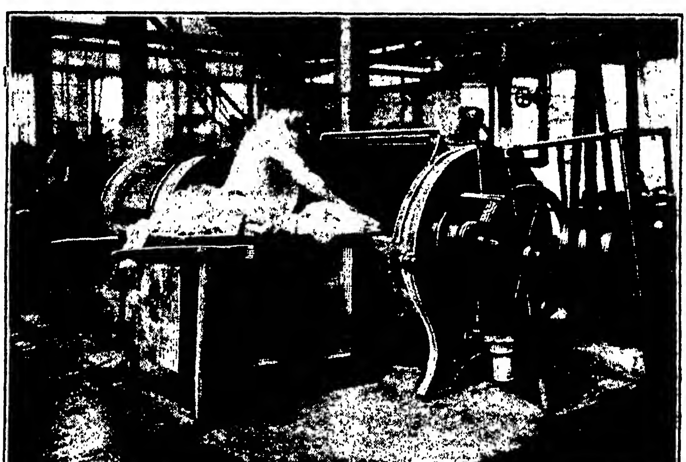
By ALEXANDER CAMERON, F.C.S.

THE steam laundry is the result of the necessity to wash and iron large quantities of linen well and quickly. By mechanical power it has now become possible to deal with thousands of articles as easily, or more easily, than hundreds are treated by hand washing and ironing, and this is accomplished by means of modern appliances for washing, drying, and ironing in bulk without departing from a high standard of work.

Steam laundry work has often been deprecated and the quality compared with that of hand laundries, but each method produces excellent results in intelligent hands, and neither can really claim advantage from the point of view of quality, while the steam or power laundry has decided superiority in speed. At the same time it must not be forgotten that even in a steam laundry many articles must of necessity be treated entirely by hand, being too delicate in fabric or colour to warrant their being lost sight of even for a few minutes.

Collection of Work. Work is collected by districts termed *journeys*, and the work of each district is sorted and kept together throughout the various processes, so that the articles to be sent to a definite district are ready for despatch at the same time and one delivery will serve. This is important when the question of expense of cartage is considered.

Before they are washed a distinguishing mark is put on each customer's goods. This may be the number of the customer's basket, or, in the case of goods coming in in batches, they are marked by running numbers, which may be prefixed by a letter to prevent the numbers running too high. Or the letter may denote a district or shop from which linen is collected. The numbers are sewn on the articles neatly, and should not be written in ink, as, when the laundry is changed, the ink-marks cannot be removed. Ink is scarcely an objection, however, on collars, cuffs, or shirts. Fine cambric handkerchiefs should not be marked at all except by a mark sewn on the edge and removable, or the articles may be washed in a net and ironed off together and taken direct to the packing-room.



15. WASHING MACHINE
This series of photographs was taken at the Rochester Laundry, London, N.W.

Sorting. Sorting is a very important process. The usual classification is described on page 2590, but in a large laundry the classes must, as a rule, be further subdivided. For instance, tablecloths are washed apart from napkins, shirts from collars, for the reason that the smaller articles become rolled up in the larger and fail to be thoroughly cleansed.

The required times of delivery must be carefully watched when the goods enter the laundry, and those wanted early in the week or within a few hours must be treated first. Linen is collected on Monday and Tuesday from families, and delivery is wanted from and after Wednesday evening. The early lots are sent first to the wash-house, followed by the district "journeys," between which may be sandwiched any special lots wanted at short notice, and so on till the end of the week. When the last collection is washed, provision should be taken to keep the machines employed on work collected towards the end of the week, of which delivery is wanted by about Tuesday. This keeps all the plant of a laundry fully occupied continuously during working hours, and is an important economy which would otherwise be missed.

The sorters should be made responsible for the same lots of linen each week, so as to become thoroughly acquainted with the peculiarities of each customer's wishes and to gain a knowledge of the linen and the marks, thereby becoming expert in their work. If hotel work ing daily collection, washing, and despatch be undertaken, special sorters should be reserved and not put on the general work of the laundry. Hotel work, too, should be kept in a special department, and not mixed with the ordinary family washing.

Washing. The usual type of machine is the *rotary*, which consists of an outer and inner cage. The articles to be washed are placed in the inner compartment, and this inner cage revolves in alternate directions, causing the clothes to be thoroughly washed by ensuring that every surface is presented to the washing liquor. Washing, rinsing, bluing, and starching is done in these machines without removal or touching by hand [15].

In washing a load of sheets, for example, the process is as follows: The sheets are taken, shaken out and placed one by one in the machine till it is almost full of dry work. The door of the cage is then closed, and water is admitted by a pipe connected with the water supply. The machine is set in motion, and the supply of water is stopped when the machine is half, or almost half, full. After running ten minutes this first water is run off, and more clean water is run in until the machine is one-third full.

16. SINGLE-ROLLER IRONING MACHINE

Steam is then turned on so as to raise the contents of the machine to boiling point in about eight or ten minutes. A good-sized machine is capable of dealing with 60 sheets at a time, but the machines may be larger or smaller. About 1½ lb. of soda in dry powder is then added, while the machine is in motion—anything can be put into the ironing machine *when the machine is revolving towards the attendant.* Then a solution of soap containing about 1 to 1½ lb. of a good hard tallow soap is added. If a permanent lather be not produced by this quantity of soap, more is added to produce and maintain the lather, but a short time must be given to allow of its formation. The addition of too much soap is shown by the suds exuding from the machine to the floor of the wash-house. The correct quantity is added when the suds come to the lip of the machine, but do not come over. After the soap is added, the liquor should be brought to the boiling point as quickly as possible, and the boiling maintained for about five minutes. After a further five minutes' run in the hot liquor, the sluice may be opened and the liquor run away to the drains.

When the machine is almost dry, stop it and run up with warm water, or with cold water and a little steam. This is the first rinse, and the water should be up to the level of the lip of the machine. Abundance of water means a good colour imparted to the linen. The machine is allowed to revolve 10 minutes in this first rinse, which is then run away, and two subsequent cold and similar rinses are given, lasting five minutes each, to the latter of which a little blue solution is added till the requisite blue colour is obtained. From the water of the last rinse the clothes are removed into a trolley, after which they are "hydroed." This operation will be described later.

There are, of course, many varieties of washing machines. They may be of either wood or brass, or both. All metal washers cost about three times as much as the wooden machines, and last at least three or four times as long. About 15 to 20 years may be taken as the life of an all-metal washing machine. Wooden machines wash well, but the repairs are apt to be troublesome. All projections within the cage likely to catch the linen should be avoided in purchasing a machine. The perforations should be bevelled so as to offer a smooth surface. Wooden knuckles or projections on the wooden machines are of doubtful value, as they may roughen and tear the surface of the linen. The sluice should be about 3 in. in diameter to allow the water to leave the machine quickly when done with. The doors should open nearly the whole width of the machine, and may be sliding or lifting. As the whole weight of the wet linen in the cage is borne on the bearings, the construction of these is important; they should be broad, well supported, and provided with cups to prevent the entrance of lubricating oil to the machines.

Drying. Drying is usually termed "hydroing" in a steam laundry. A hydro extractor consists of an outer cover within which a cage may be made to spin. The clothes to be dried are placed within this cage, which is caused to revolve by means of a belt attachment. The faster this cage revolves the greater the tendency of the clothes to fly out. The sides of the cage prevent this, but the perforations in the side of the cage allow the water, which is released by the pressure of the clothes against the side, to escape to the drain. The cage revolves about 1,000 times each minute, and by the time it has revolved 10 minutes at full speed the articles may be removed. Sheets are then dry enough to iron without further drying in dry-rooms. Table-linen is treated in the same way, but the hydroing is continued at least five minutes longer. Shirts

and similar articles are thoroughly dried in drying-rooms after being hydroed [17].

Sometimes articles are simply hung up in the laundry to dry. But this is, as a rule, slow and unsatisfactory because of dust. The simplest form of drying apparatus is a room into which hot air is forced from a heater by means of a fan, and the supply of which is regulated by means of a valve. A temperature of about 100° F. in a room in which the air is changed every half-minute is sufficient to dry a roomful in about 20 minutes. The rooms are conveniently built about 16 ft. by 12 ft. by 8 ft. It is not advisable to dry at a much higher temperature than 100° F. A good blanket drying-room can be arranged above the linen drying-room, so that the air which is used to dry the linen may be allowed to go into the upper room where the blankets or flannels are hung. This cooler air will dry blankets well. The hot-air entrance should be at the top end of the drying-room and the exit at the lower end. The door should be made to shut tight.

Ironing. Nearly all flat work, such as sheets, may be ironed in calenders. These calenders are iron rollers covered with felt revolving in a hollow steel polished bed. The sheets are fed in evenly through a "lip" on one side, and are dried and ironed between the roller and bed, which are kept hot by means of steam. One-roller machines are the most common, but many others are made with two or more rollers. For an ordinary family steam laundry the single-roller machine is the best [16]; but if the business grows, the addition of a multiple-roller machine is a great advantage. The former turns out starched table-linen to better advantage than the latter, but for unstarched flat work the latter is by far the better machine. It turns out the work more rapidly, and is more economical to dress with felt. The multiple-roller machine is usually heated only in the bed, and the space between the rollers allows the moist vapours to escape rapidly. Anything between 10,000 and 15,000 articles may be ironed in a multiple-roller machine in a working day of 10 hours.

17. HYDRO EXTRACTOR

Body linen and lace-trimmed articles are ironed on tables by ordinary flat-irons heated on a coke stove or by gas-irons, of which there are a number of good makes.

Shirts and collars are ironed on special machines as regards the fronts and cuffs. A table slides backwards and forwards below a gas-heated polished roller, and the front of a shirt placed on the table may be ironed by simply hol[ding it in] position. Collars and cuffs are similarl[y ironed.] The body of a shirt may be ironed by hand or by means of a specially constructed machine.

Many machines are on the market to save labour in all possible directions. Sometimes, however, labour is saved at the expense of more than the equivalent in gas and machinery, not to speak of depreciation in quality. It is a safe thing for a beginner in steam laundry work to put in only the essential machines at the beginning, and to add the others as he finds he can economically or advantageously use them.

Driving Power. The driving power should be selected with care. The cost of driving depends on the cost of fuel and the amount of it consumed. The ordinary form of steam-engine will consume about 10 or 15 times as much fuel as the more modern forms of gas or oil engines. But nearly any engine-driver can drive a steam-engine, whereas a competent man is necessary to attend properly to an engine burning suction gas or oil. These latter engines are now running at an expense of about one-tenth of a penny per brake horse-power per hour. Even a large steam-engine as used in an electric generating station will cost three farthings per brake horse-power per hour. The claims of the suction gas plant should be carefully considered before buying any other form of power for running the machinery of a laundry. Electricity, even at the rate of one penny per unit, and a further discount for quantity consumed, can hardly compete with suction gas or oil.

For instance, if a 40 brake horse power suction gas or oil engine be run for a normal week of 60 hours, the actual cost of fuel will be about 20s. to 23s.; taking oil at 50s. per ton, and anthracite at 23s. per ton. Burning town gas, such an engine would cost to run about 90s. per 60 hours. A good modern steam-engine would cost about £10, and a set of electric motors about £7 for the week.

Steam. If a chimney shaft be not an objection, a good form of boiler is the two-flue Lancashire. Laundries use a lot of steam, so that the boiler should be of large size. A large boiler is much more economical than a small one. As steam is an expensive item, care should be taken to choose the best form of coal—to keep the boiler inside free from scale, the tubes (if any)

free from soot, the draught to the chimney under control, and the outside of the boiler and main steam-pipes insulated.

There is a large amount of water condensed from the calenders, and this should not be allowed to run to waste, but ought to be collected for use in the steam boiler, or for washing flannels if preferred.

18. SHIRT AND COLLAR IRONING

If the laundry is specially built, let it be on one floor if possible, so as to dispense, as far as possible, with the need of forewomen. There need be no partitions. The office can be of glass, and should of course be near the door. Any first-class firm of laundry engineers will supply plans of machinery installation to suit any building. But it is a great advantage if the laundryman is himself an engineer.

Cost of Machinery. It is often asked: what will it cost to lay down plant to do work equal to a turnover of £50 per week, or £100 per week? Until the class of work to be undertaken is known, an answer cannot be given. Some laundrymen can get one class of work and not another, and they must lay their plans accordingly. For family work amounting to £50 a week at best London prices, an outfit may cost £900, and the building £900 extra. If these prices cannot be obtained, the cost of the outfit may be doubled to obtain the desired result. Cheap machinery may be bought and the expense reduced somewhat. But for a turnover of £50 per week at an outlay of £900 for the machinery and £900 for the building, and a few hundred pounds for working capital, a return of, say, £300 a year should be obtained if the proprietor is his own manager. It is advisable, however, to spend more on the premises, so as to leave room for future extension. Of course, doubling the turnover in high-class work materially increases the rate of profit, and a net result of 25 per cent. return on the capital invested should eventually be obtained when only high-class work is undertaken.

Staff. A saving should not be attempted by employing cheap labour. The public is educated to demand good work, and will go where the work is good. Wages vary according to district, and inquiry should first be made as to the rates before the laundry is started, also as to the supply.

Bookkeeping. The books usually kept in a business are essential also in a laundry, and a rough balance-sheet, showing the income and the expenditure under the various headings, should be got out weekly.

By this means, the amount of the various materials used and the amount spent in wages can be seen at a glance, and any leakage at once checked. Wages are the heavy item. It is usually about one-half of the expenditure, but the lower the wage percentage is, of course, the better. A good family laundry can be run at about 40 per cent. The amount of the outstanding debts can also be seen by having a balance-sheet, and the prolonged credit so often asked by customers prevented to a large extent.

Claims form a very important item in the trade accounts. Some are justified—some are not. It is often difficult to distinguish between them. Unjust claims are often made to obtain prolonged credit, and the payment of several pounds kept back pending the settlement of the loss of a handkerchief. It is better not to let these accumulate, but to settle at once when a decision is come to as to validity.

Customers generally enter their linen in books provided by the laundry, and it pays the laundry to supply properly ruled books. If the numbers do not tally exactly with the number of articles entered in the book, then a counter-entry should be made and checked by another sorter, to ensure accuracy of the count. Care in this saves a great deal of time.

Date Sent ______________________ 190

No. of Articles.	Description of Articles	No. Returned.	Rate.	£	s.	d.

Laundry concluded

Continued from page 2821

THE VIOLONCELLO

Compass of the Instrument. Tuning. Correct Attitude of the Player. Open Notes and Positions. Bowing. Exercises

By ALGERNON ROSE

THE violoncello, or the 'cello, as it is commonly called, has four strings. As the character of their tone depends not alone on the tension, length and substance, but thickness, the strings are of different gauges. The material in ancient lutes may have been furnished from the intestines of cats, but the substance nowadays preferred is derived from young lambs, although goats, antelopes, and deer are laid under contribution. Increasing weight and depth of tone are gained by the two lower 'cello strings being covered with copper or silver wire.

Compass. The names of most of the parts of the violoncello are similar to those of the violin [page 2121]. If the viola extends the compass of the violin a fifth downwards, the 'cello continues that of the viola an octave further. The four strings are tuned in fifths. That on the left of the player is A (fifth line, bass clef). The next is D (third line), the third is G (first line), and the lowest is C (second ledger line below staff). Thus, the pitch of the top string is an octave below that of an A tuning fork.

Tune the strings in succession from the A, each a fifth lower than its neighbour. Correct their pitch at first by the notes of a piano, or by a set of pitch pipes. When properly tuned, these four strings give the "open" sounds of the instrument. In music they are indicated by a zero above each note.

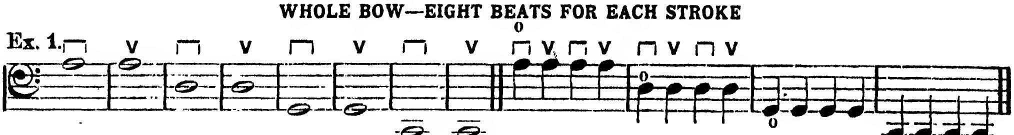
Attitude of the Player. Sit on the fore part of a chair. Advance the left foot, which should be turned outwards. Draw in the right foot. Rest the left edge of the instrument against the calf of the left leg. Steady the right edge by the calf of the right leg. Grasp the 'cello firmly, so that the bow, when crossing the strings, may not touch the left knee. The instrument should be held securely in this way, so that the left fingers may be free to stop the notes firmly, and the entire hand change its position without having to support a heavy weight.

The Tail Peg. To ensure that the 'cello does not slip whilst being played upon, it is customary nowadays, especially with ladies who cannot hold the instrument in the way described, to use a steel or wooden stem, protruding 7 in. or 8 in. from the tail-end. This dispenses with the pressure of the legs, and leaves the body of the 'cello free to vibrate. The stem should be adjusted to such a height that the bow will not touch the left knee nor the right thigh when the first or the fourth string is sounded.

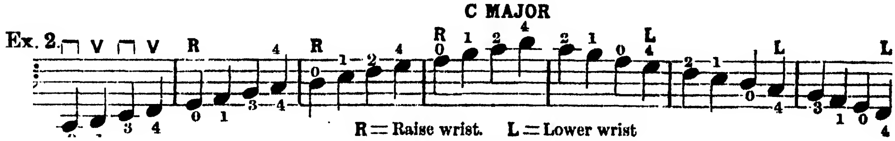
When in position, the scroll, or head of the 'cello should slant over the left shoulder. Place the thumb on the centre of the back of the neck of the instrument. Put the tip of the first finger on the first string on the fingerboard above and opposite to the thumb. Press down the tips of the second, third, and fourth fingers. Round the joints well on the third string; do not let them sink in. If the finger tips are not employed, the hand will not be properly rounded. Continue this exercise by putting the first finger and others in succession on the second string. Transfer them in the same way to the third and fourth strings. Make each movement emphatically.

Having well resined the hair, take up the bow with the right hand by the nut, or screw end. Hold the stick between the thumb and second finger. Let the inside of the hair touch the first joint of the middle of the first finger. The third and fourth fingers are used to balance the bow, and the first finger to give the necessary pressure on the strings. All movements with the bow must be done with a graceful wrist. The motions of raising, lowering, and turning the

WHOLE BOW—EIGHT BEATS FOR EACH STROKE

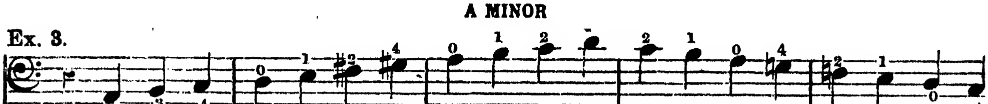
Ex. 1.


C MAJOR

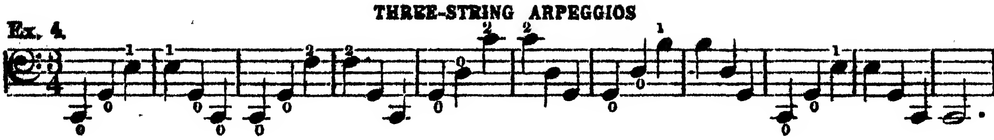
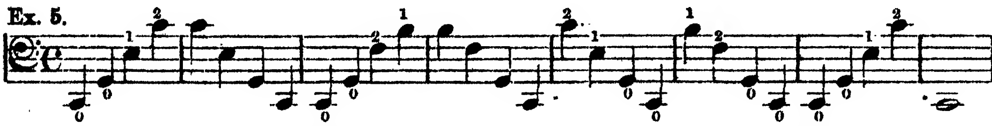
Ex. 2.


R = Raise wrist. L = Lower wrist

A MINOR

Ex. 3.


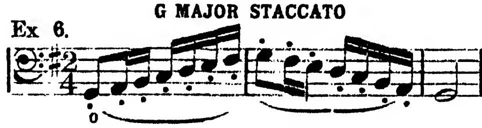
THREE-STRING ARPEGGIOS

Ex. 4.

Ex. 5.

right wrist should be carefully practised—anything stiff or inflexible looks bad. Pains should be taken at first to keep the bow uniformly about an inch above the bridge at right angles to the instrument.

Exercise on Open Notes. Place the nut of the bow on the first string. Move the hair parallel with the bridge. Count eight slowly till the bow arrives at the tip. Meanwhile, the nut should not have been raised towards the finger-board nor permitted to slant downwards. Keep the right elbow free, and the upper part of the arm close to the body, but do not move the shoulder. Return in the same way with the "up" bow, without lifting the bow off the string. Make the hair bite equally the whole length. Bow the other three open notes clearly in the same way, using the whole length of the hair. A down-bow, it will be understood, is from left to right, the up-bow being from right to left. The former is denoted in music thus, ┌┐, or Λ, and the latter by └┘ or V. When a change occurs from one string to another, it should be made cleanly by the motion of the wrist. Curve the latter outwards when playing on the first string, and inwards on the fourth string [Ex. 1].

C Major. Now essay the scale of C major [Ex. 2]. Begin with the down-bow on the open note of the fourth string. Depress the first finger of the left hand firmly. Get with an up-bow the note D, a whole tone above the C. Next, put down the third finger and stop E, another whole tone, playing with the down-bow. The F being at the distance of only a half-tone, does not require the same stretch. For this, put down the fourth finger and use the up-bow. Go to the third string. With the wrist raised, play the open note G. The first finger will give the A above and the third finger the B. C, only a semitone higher, will be stopped with the fourth. The motions of the bow, wrist, and fingers should be simultaneous. Continuing on the second string, play the open note D. Use the first finger for E. As the next note is but half a tone away, put down the second finger for F. Stop the G with the fourth. Without break, sound the open note A of the first string. Make the B above it with the first finger, the C with the second, and the D above with the fourth. When

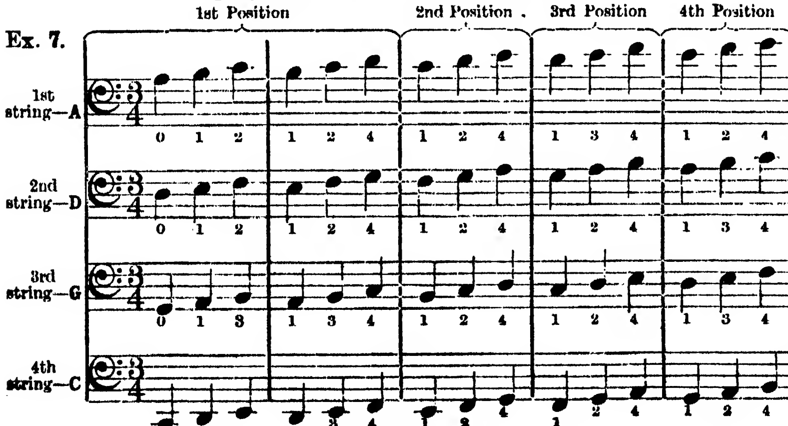
G MAJOR STACCATO

Ex 6.

passing from one string to another, avoid unnecessary finger motions. If not carefully checked, fussy movements develop into affectations.

The First Position. Now go back with the same fingering. Do not continually raise the bow for successive notes. Balance it firmly. When the strings are changed, the sound should continue, whether the bow is at its tip, nut, or any other part. Throughout this scale, the hand is situated in what is known as the *first position.* Ex. 3 gives the fingering in one octave of the relative minor scale A. By this it will be seen that although the F and G are sharpened when ascending, the same digits are used.

FINGERING OF THE FOUR POSITIONS

Ex. 7.

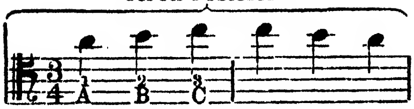


If reference is made to the course on Theory or the Violin, the student will understand how the fingers which stop the notes, when playing the major and their relative minor scales, must allow certain half-tones to alternate with the series of whole tones. The stretch of the finger at definite points in each scale, therefore, is less than during the remainder of the progression.

FIFTH POSITION

Ex. 8.

1st string



Finger Stretching. Ability to extend correctly the left-hand fingers is an essential in 'cello playing. While the first and second fingers open freely from each other, it will be found difficult at first, owing to the muscles and shape of the hand, to extend the third finger beyond the distance of a semitone from the second. To overcome this awkwardness, 'cello students sometimes add to their stretch by placing corks between the second and third and third and fourth fingers. Try small corks at first, and avoid straining the fingers in any way. As the opening between the digits gradually widens, the span can be still further increased by inserting larger corks.

Arpeggios. Take the major and minor scales already given, and delete certain of the notes. [See Ex. **4**.]

After practising the arpeggios over three strings, extend them over the four, as in Ex. **5**.

Wherever the second and third fingers are used, or the third and fourth, give special attention to them. It is only by practice that the beginner can hope to make the weaker digits as serviceable as their stronger brethren. Equality of strength and independence should be the constant aim in view.

Bowing. To add to the suppleness of the right wrist, practise each exercise, whether scales or arpeggios, by bowing every note first with a separate stroke. When ability to do this evenly has been acquired, the same exercise can be varied by linking together two notes with one bow. Then, with one bow, play three notes, three and two, two and three, eight notes, two with one bow and the two following with two short bows, a group of four notes with one stroke, and the succeeding four with four short strokes. Further variation can be obtained by tying a succession of notes together smoothly with one long stroke. Then, make a similar number of notes staccato, either with one bow, or with the point and heel of the bow alternately.

Staccato. Staccato bowing is done usually with an up-bow near the tip. It is executed with a rigid arm. Each sound must be articulated by a special pressure whilst the wrist remains supple [Ex. **6**].

Such exercises should not be done promiscuously, but systematically. The middle, the whole length, and the extremes of the bow should all be studied with the greatest care.

The thoughtful student who compiles his own exercises methodically, so as to strengthen and accelerate his execution, will make more progress than the pupil who ignores the study of theory and plays in a casual manner many published studies without perceiving their object. The object in view can never be attained without a careful perception of the motive aimed at. Amateurs frequently fail to advance in 'cello playing as they should do because they will not take the instrument seriously. Those difficulties which must be overcome if progress is to be made need first to be comprehended. This calls for mental as well as physical exertion.

Steady Repetition. It is by thoughtful rather than by merely mechanical practice that the hands can be properly trained, so that they do ultimately what is required, as if automatically. It is of little use to practise strenuously several hours one day in a week and neglect opportunities for study every other day. Far better concentrate the attention regularly on the instrument for half an hour every day, and draw up a system of profitable study.

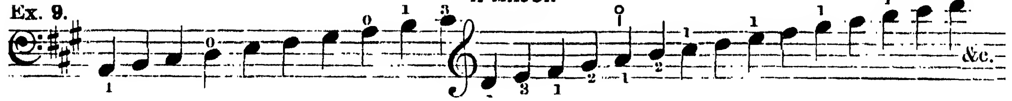
Positions. Having become familiar with the fingering of the *first* position, the student should leave the open strings and proceed to the fingering of the *second*, *third*, and *fourth positions*. "In each position," says Duport, "the hand must preserve the same form as it took in the first, and the fingers must likewise maintain their respective distance, except their insensible and necessary approachment to each other in moving towards the bridge, owing to the stops becoming gradually closer." The fingering of the notes in the four positions is demonstrated in Ex. **7**.

Those studies which the student may have already devised for the first position can be used for the higher shifts if transposed [see TRANSPOSITION]. These exercises will suggest fresh studies. When the technical gymnastics of any instrument have been mastered, the playing of melodies and other pieces will be found comparatively simple. In shifting from one position to another, the thumb must follow the hand lightly, touching the neck.

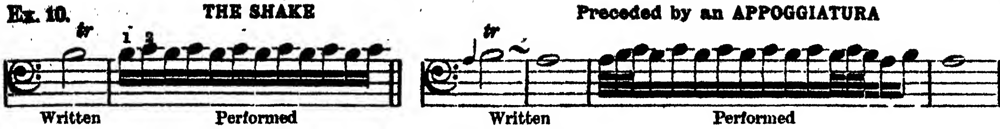
Tenor Clef. Hitherto, in the four positions, the bass clef has been employed. If that system of notation is continued for the higher shifts, the number of ledger lines above the staff becomes confusing. When, therefore, the fifth position is reached, the tenor, or C clef (C on the fourth line) is used [Ex. **8**].

Beyond the A (first space above first ledger line) for extreme passages, it is customary to employ the G, or treble clef [Ex. **9**].

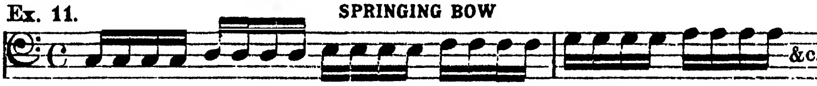
A MAJOR

Ex. 9.

In certain old scores the treble clef was sometimes written in 'cello parts an octave higher than the actual sounds, a system unnecessarily perplexing.

Thumb Positions. To make use of the extensive compass of the violoncello, the thumb, instead of being kept at the back of the neck, is

Ex. 10. THE SHAKE — Preceded by an APPOGGIATURA

brought round to the front of the fingerboard. During the last note, before employing the thumb, its place is changed from behind the neck. It is held above the string at a tone's interval from the first finger. It then slides into its place horizontally upon the strings, and parallel to the bridge, so that two strings are touched at once. The middle of the thumb nail is over the lower string, and the first joint of the thumb over the higher string. Rest the left arm lightly on the side of the 'cello. Having thus made a position barrée [see GUITAR], stop the notes above with the first, second, third, and fourth fingers. The sign denoting the use of the thumb is printed thus ♀. When "same position" occurs after this sign, it means that the thumb must remain in the same place.

Orchestral Playing. If the student, presumably, is qualifying himself to take part in an orchestra, the thumb positions, the playing of harmonics, and those subtleties of expression in bowing cultivated by the soloist need not occupy the attention of the learner so much as the two lowest octaves of his instrument. These have the richest tone and most telling qualities, whereas in orchestral work the two highest octaves of the 'cello are seldom wanted.

Ex. 11. SPRINGING BOW

Solo Playing. Although the solo 'cellist who is really great is rare compared with the violinist, the ambitious student will not rest contented until he has familiarised himself with exceptional fingerings and bowings.

The Shakes. The shake, chain shakes, and passing shake must all be done with an even finger-motion, and practised till the movements are extremely rapid, although the bowing is done slowly [Ex. 10].

For the "springing bow," the lower middle part is usually employed. The arm and wrist must be free and lissom. Give a little extra vehemence to the first note of a group [Ex. 11].

The Vocal Quality. Nevertheless, it is well to remember that the greatest charm of the 'cello, when well played, consists in its power of gliding from one note to another, and of its peculiar vocal quality when dwelling on a note, closely imitative of the human voice. This sympathetic effect is heard to the best advantage in the lowest register of the instrument in slow passages, and it is that part of its compass which, in the orchestra, is of greatest value.

Violoncello concluded

Continued from page 2822

INDIA & THE CHINESE EMPIRE

Southern India. Indo-China. Climate, River Basins, Products and Towns of China. Manchuria and Mongolia. Turkestan, Tibet and Korea

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

The Native States of Haiderabad and Mysore. The large state of Haiderabad occupies the centre of the Deccan. Much of its surface consists of plains of black cotton soil, separated by low, flat-topped basalt hills. It is much drier than the Central Provinces, and there is little forest. The whole country is dotted with tanks to store water for irrigation. The rivers Godavari and Kistna cut gorges in their descent to the alluvial plains of Madras. Cotton is an important crop. Many ancient and beautiful manufactures are carried on; but as coal is abundant these may ultimately be displaced by the far less admirable products of machinery. The capital is Haiderabad, in a stony plain. Secunderabad, in the immediate neighbourhood, is a British military station.

Mysore is also a high undulating region with many isolated rocky hills. Forests clothe the wetter western hills, producing sandalwood and other valuable timbers. Coffee is largely cultivated. Of minerals, gold is the most important. The chief cities are Bangalore and Mysore.

Madras. Nearly all the rest of India is included in Madras, the surface of which is extremely varied. The west is high, sinking to the coastal plains of the Coromandel coast in the east. In the south the forested Nilgiris, the home of little-known aboriginal peoples, are separated from the Cardamom Hills by the Palghat Gap, an important route across Southern India traversed by a railway from Madras. The richest parts of Madras are the lower courses and deltas of the Godavari, Mahanadi, Kistna, Cauvery and other rivers from the plateau. The plateau area resembles Mysore. The mountains and hills of the west are covered with dense forests, supplying beautiful cabinet woods. Gold and precious stones are found, but no coal. Wheat is not grown so far south, but most other Indian crops succeed. Coffee and some tea are cultivated in the western hills. The tobacco of Southern India is well known. Madras, on the surf-beaten east coast, is the third city of India. Trichinopoli, on the Cauvery delta, manufactures tobacco. A great temple-crowned rock gives the city an imposing appearance. Southern India contains many magnificent temples, the finest being at Tanjore and Madura.

Ceylon. The south of Ceylon is mountainous, rising to over 8,000 ft., and densely forested. Adam's Peak is the most famous, though not the highest mountain. The climate is hot at all seasons, and the rainfall heavy except in parts of the north-west and south-east, in the lee of the mountains. Vegetation is entirely tropical in character, palms preponderating. The coconut palm supplies coir or fibre, oil, and copra—the dried flesh of the nut. Enormous quantities of tea are cultivated on the cleared hill-slopes. Many spices are also grown. Colombo, the capital and chief port, is on the west coast. Kandy is finely situated on the forested hills of the interior. Trincomalee, on the north-east coast, is a British coaling station.

Indian Islands. Rising from the seas west of Southern India are the coral Laccadive and Maldive islands. Only a few are inhabited. Vegetation consists chiefly of coconut palms. Midway in the Bay of Bengal are the forested Andaman and Nicobar Islands, the homes of primitive tribes.

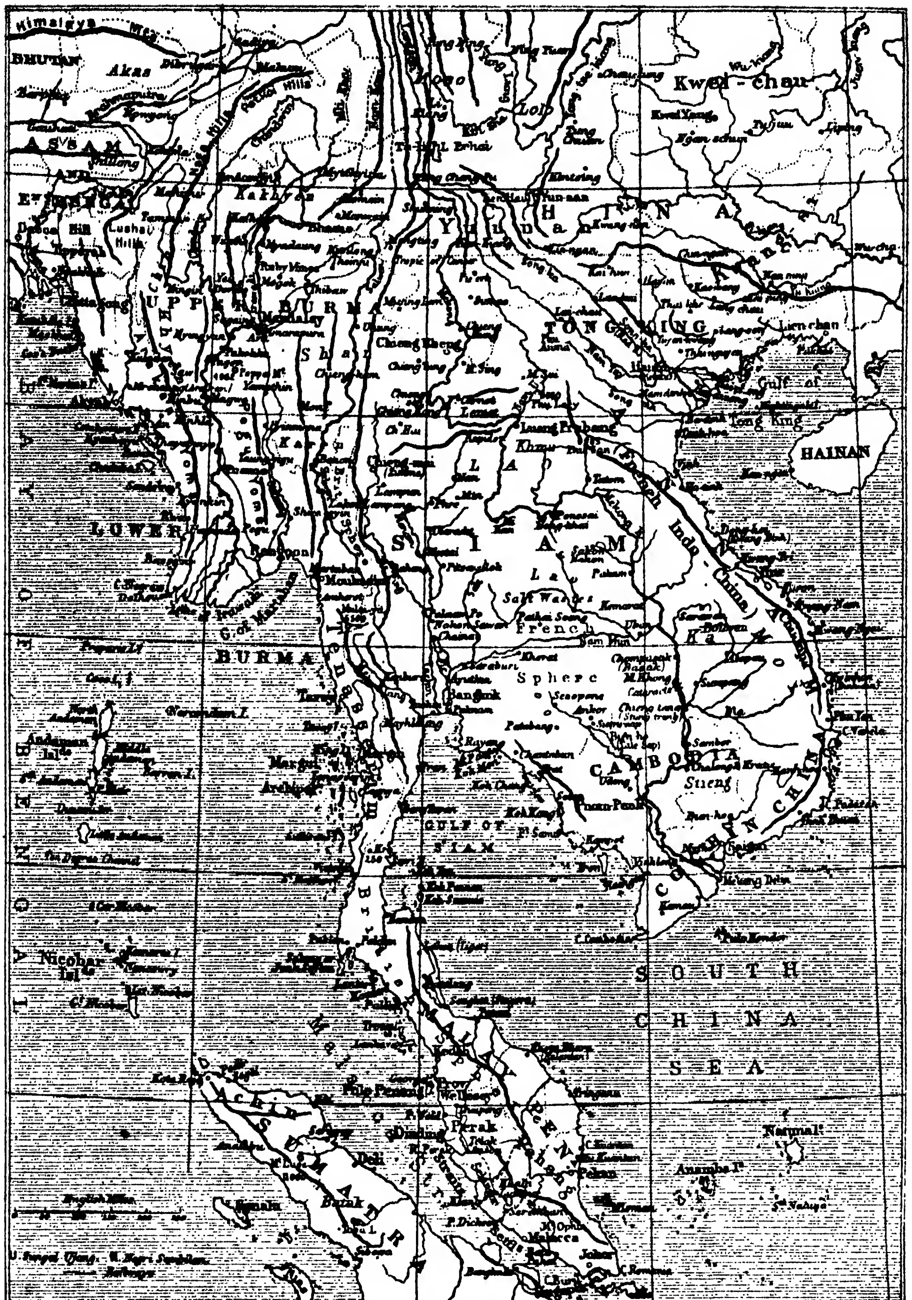
Assam. The forested mountain province of Assam is traversed by the valley of the Brahmaputra, which descends from the bleak plateau of Tibet to the steamy lowlands of the Ganges delta. Much tea is grown in the clearings of the forests, which supply sal and other valuable timber. The seat of government is Shillong, in the Khasi Hills, which contain deposits of coal and petroleum.

Burma. Upper Burma is a region of wild, forested mountains, the home of many uncivilised tribes. The forest produce is very valuable. Teak, one of the most durable of timbers, is, owing to its great weight, floated down the rivers to the coast, where elephants are used to pile it. The rubies of Upper Burma are famous for their fine colour. Lower Burma consists of the fertile deltas of the Irawadi and Salwen, both great rice-growing regions.

The Irawadi rises by several streams in the mountains east of Assam, and flows through forested hills, forming picturesque defiles in its course to the sea. It is navigable from Bhamo, 700 miles from the coast. The chief towns of the Irawadi are Mandalay, the old capital of Upper Burma, and Prome. Rangoon, the capital, on the Rangoon river, 20 miles from the sea, is connected by a creek with the delta. It has a large export trade in teak and rice. The Salwen flows from Eastern Tibet, through little-known forested mountains. In the Shan States, on the Chinese border, the cultivation of wheat is becoming important. Teak from the forests and rice from the delta are the exports of Moulmein on the estuary of the Salwen.

INDO-CHINA

Siam. The independent kingdom of Siam occupies the region between Burma and French Indo-China, the Mekong forming the boundary between the two for a considerable distance. The Menam delta is the mainstay of Siam and



100 Long. East of Greenwich

117. INDO-CHINA

the chief support of its population and trade. The capital of the country is Bangkok, a squalid little town resembling Venice, with water streets and houses raised on piles above the swampy delta flats. This type of house is common throughout Malaysia.

Malay Peninsula. In the extreme south of the Malay Peninsula is the British Straits Settlement, with the great port of Singapore on a neighbouring island. The whole region resembles Burma. The rich forests supply many valuable products. Rice is the staple cultivated

plant in the deltaic lowlands. The Malay Peninsula and small adjacent islands supply the world with tin.

The richest parts of French Indo-China are Tongking, the fertile delta of the Red River, with Hanoi as the capital, and Cambodia, the delta of the Mekong, with capital Saigon [117].

THE CHINESE EMPIRE

The Chinese Empire (4,280,000 sq. miles) consists of China proper and of the dependencies of Manchuria and Mongolia on the north, Turkestan in the west, and Tibet in the south-west [118]. Much of the dependencies is desert or lofty mountain, giving China a strong, natural western bulwark against aggression.

China. This country lies on the eastern slope of the Central Asian highland region, and includes the fertile alluvial lands made by the rivers which drain these highlands east to the Pacific. The largest are the Hwang-ho in North China, the Yang-tse-kiang in Central China, and the Si-kiang in South China. The western provinces are mountainous, but eastern China consists in large part of the fertile lowlands of these and smaller rivers.

Climate. Peking, the capital of China, situated near its northern limit, is in the latitude of Southern Italy. Its mean annual temperature is that of London, though its summers are much hotter and its winters much colder. The winter climate of the northern half of China is made severe by the prevailing north-west winds from the highlands of Central Asia. The northern rivers are frozen in winter, and even Shanghai, in the latitude of Tripoli and Jerusalem, has severe winter frosts. The climate of Southern China, which is crossed by the Tropic of Cancer, is tropical.

China lies in the monsoon region, and the consequent regularity of the seasons early made agriculture important. The Chinese regard this as the most honourable of human occupations, and wisely so, for the prosperity of their teeming population depends wholly on the patient and laborious cultivation in which the Chinese excel. The crops raised are very various. In Northern China wheat and millet—one species taller than a man—are the cereals. Rice is not grown north of the Tsingling Mountains, which separate the Hwang-ho and Yang-tse basins. Central China produces rice, tea, cotton, silk and opium. Sugar, indigo and spices are grown in the tropical provinces of South China.

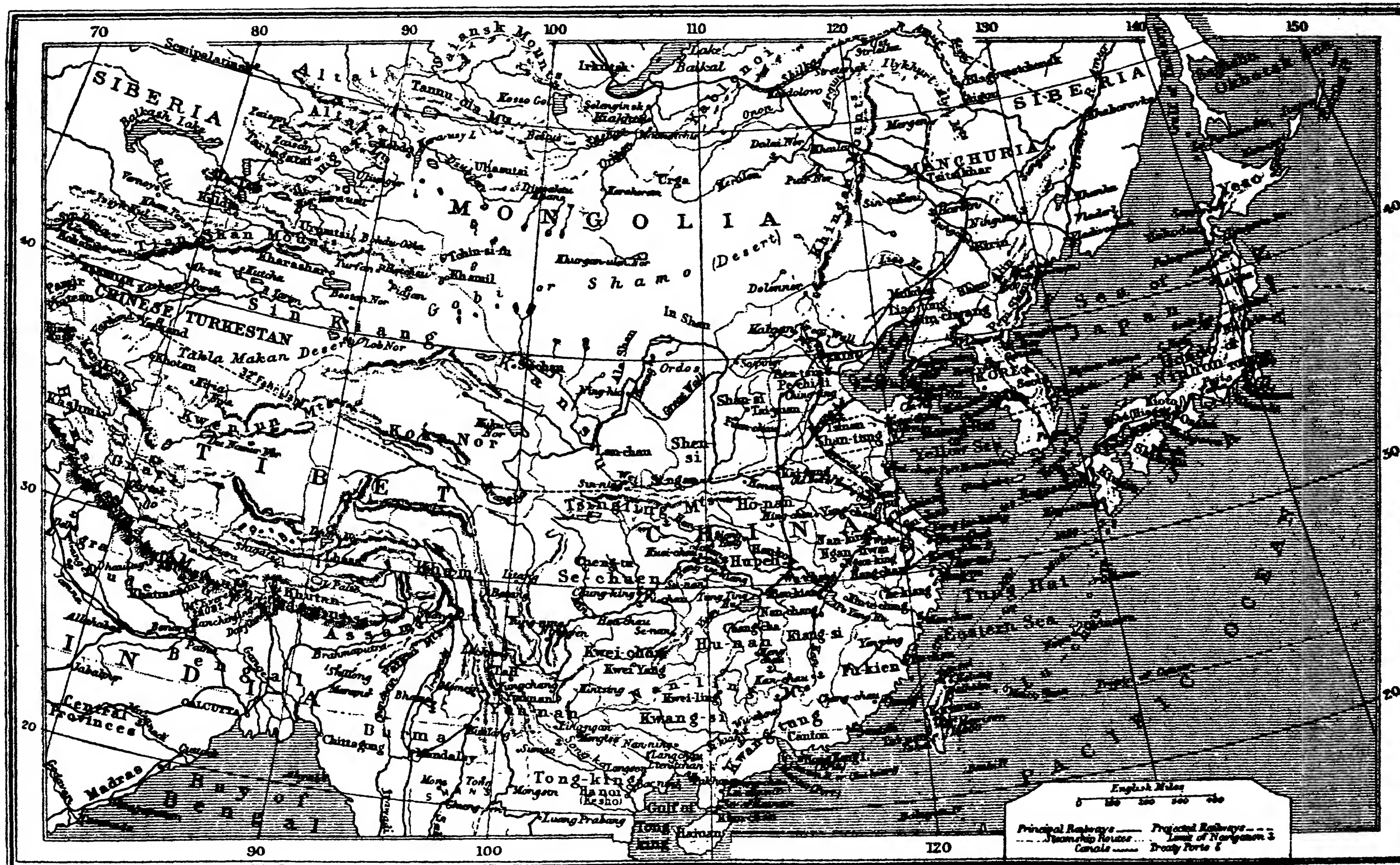
Many Chinese trees—the oak, maple, poplar—we know, but others—the useful wax, tallow, soap, and varnish trees, etc.—are unfamiliar. The beauty of the azaleas and other flowering shrubs explains its title of the Flowery Land.

The Yellow Lands of North China. The yellow or loess lands of North China are indescribably fertile. All that they require is a little fresh sprinkling of their own loam on the surface, and they bear crop after crop with undiminished fertility. The origin of this fertile soil is very interesting. In the course of many ages the winter gales have swept it down as fine sand from the mountains and deserts of Central Asia, filling up the hollows and valleys of the old land surface and gradually levelling it. In the process layer after layer of grass and other vegetation has been steadily but imperceptibly buried. The decay of this has added fertilising substances to the soil, which has been rendered still more light and porous by the disappearance of the buried plants. Water sinks easily through such ground, dissolving the chemical substances present, and forming a kind of natural liquid manure.

A Strange Country. This fertile yellow soil has certain disadvantages. The rivers cut their channels deeper and deeper through the loose soil, and flow between lofty banks far below the surface level. Similarly, the roads sink deeper and deeper below the surface, forming at last mere cracks 8 ft. or 10 ft. broad, winding between walls perhaps 100 ft. high. Seen from above, the country seems to be densely cultivated, but uninhabited, for the dwellings are out of sight along the invisible roads. Irrigation would obviously be impossible; but, fortunately, the rain is ample for cultivation.

The Hwang-ho Basin of North China. The Hwang-ho, or Yellow River [119], rises in the Kwenlun Mountains, and cuts its way down in gorges easier to imagine than to describe. It makes a great bend along the base of the Alashan, and turns south through mountain defiles between the Chinese provinces Shensi and Shansi. The Wei comes in from the mountains of Kansu province, which extends far into the Central Asian highlands, and the main stream changes its own direction for that of its tributary, exactly as the Rhone takes the direction of the Saône in France. The united river flows due east along the northern base of the Tsingling Mountains, draining the lowlands of Pechili and Honan, between which the mountainous peninsula of Shantung, with the foreign settlements of Wei-hai-wei and Kwei-chou juts out into the Yellow Sea. Wheat and millet are the staple crop—a diet which makes the Northern Chinaman taller and hardier than the men of the rice-eating provinces. The province of Shansi is destined to become the Pennsylvania of China. Inexhaustible deposits of coal and iron occur together, and the mountain rivers provide unlimited power for electrical and other industries, as well as for transport.

China's Sorrow. The lower course of the Hwang-ho is over alluvial lands built up by the river itself. To prevent it from overflowing its banks when swollen by the melting snows of the lofty mountains of Central Asia, the river is embanked. This restrains it for a time, but in the end the river triumphs. The sediment it carries must be deposited somewhere, and if embankments prevent it from spreading this out over the surrounding land, it must drop it on its own bed, the level of which is consequently always rising. As it rises the embankments rise too, and thus the river is at last far above the level of the surrounding country. "The dykes grow from mere walls into ranges of earthworks, like fortress sides, hundreds of miles long, and the effort overtaxes the skill of the engineer and



118. THE CHINESE EMPIRE

the perseverance even of Chinese labourers. When the Yellow River, gorged with water from the mountains till it forms a gigantic reservoir averaging a mile broad, from 300 to 500 miles long, and 70 ft. deep, all suspended in the air by artificial supports, comes rushing down in autumn, the slightest weakness in these supports is fatal." A tiny crack grows into a leak, the leak into a rent, the rent into a great breach, and the whole volume of water pours down with immeasurable momentum over the teeming plain below. This happened last in 1887.

"The torrent in its first and grandest rush, though throwing out rivers every moment at every incline of the land, had for its centre a stream 30 miles broad and 10 ft. deep, travelling at 20 miles an hour." For two months the Hwang-ho poured over the plains, none reaching the sea, and it is estimated that 7,000,000 persons perished. At last the water began to reach the sea, the great lake shrank to a river, and the Hwang-ho had a new course. When this happens, embanking begins again, the new bed gradually rises into the air as did the old one, and in a generation or two the calamity repeats itself. For many centuries the Hwang-ho has been China's sorrow.

Peking. North of the Hwang-ho is Pechili, drained by the Pei-ho. Here the capital, Peking, is built in a sandy plain, not far from the mountains which form the southern margin of the Mongolian plateau. It is a double city, Chinese and Tatar, both massively walled. Within the Tatar City is the Imperial City, and within that again the Forbidden City, the Imperial residence, occupied in 1901 by European troops. One result of that occupation was that the railways were brought through the Chinese city right up to the walls of the hitherto sacred Tatar City. "With its broad streets and vast, open spaces, Peking is more Central Asian than Chinese in character, and its unpaved streets are thronged by files of camels, bringing coal, wool, and other produce into the city." Tientsin, on the Pei-ho, is the port of Peking, and connected with it by rail.

The Yang-tse Basin of Central China. The Yang-tse (3,200 miles) [119] rises in Tibet, its upper course being through mountain defiles in little-known country. It enters China between the provinces of Sechuen and Yunnan, both mountainous, and its course across the former province is through gorges of great beauty, but extremely difficult of navigation.

The Red Lands of the Yang-tse. The red sandstone lands of the Yang-tse almost vie in fertility with the yellow lands of North China. Moisture is abundant, and the hills are terraced for cultivation from base to summit. Sechuen is the richest and most typical province of Central China, producing tea, rice, silk, opium, rhubarb, and other drugs, varnish, soap, wax, and tallow trees, and many other valuable products.

Chungking, built on heights where the Kialing comes in from the north, is the commercial capital of the province.

The Min Valley. The Min is remarkable for the masterly irrigation works which have converted the Chengtu plain (2,800 sq. miles), one of the few level areas of Sechuen, into the most highly cultivated and densely populated area of its size in the world. "We see innumerable water channels lined with trees, chiefly poplars, and farmhouses and residences so thickly stud the plain that they appear almost continuous. Numerous fine temples and well-endowed monasteries surrounded by groves of tall forest trees and bamboo thickets are constantly in evidence, and the whole plain and the surrounding hills afford a pleasing contrast to the tree-denuded slopes so common throughout China."

The Lower Yang-tse. At Ichang the Yang-tse leaves its famous gorges. In the remaining 960 miles of its course, though it has some hills to pass through, it falls only 130 ft. Rich alluvial plains, once perhaps old lake basins, extend on either side, and are often flooded. Hankow, at the confluence of the Han, the river of the province of Hupeh, which produces cattle and hides, will shortly be the centre of water and railway communications which will make it the Chicago of China. Every kind of produce from the vast basin of the Yang-tse is brought to its markets, and new industries and factories are constantly coming into existence. Much timber is floated down to the Yang-tse by tributaries from the mountainous province of Hunan, to the south, where much tea is grown. Kiangsi has similar products. Nganhwei grows excellent green tea, and contains some of the richest rice lands in China. Kiangsu, the delta province of the Yang-tse, is a Chinese Holland, with innumerable canals and reclaimed meadows lying below sea level. The capital is Nanking. The delta is steadily growing seawards, and in a century or so Shanghai, the port of the Yang-tse, on a river connected with the delta, will be above tidal influence. In a geographical sense it is the New Orleans of China, but in importance it compares better with New York, as it is the commercial metropolis of China. It owes its prosperity to the wealth of the Yang-tse basin, which will increase enormously when its mineral resources are systematically exploited.

Southern China. Between the basins of the Yang-tse and the Si-kiang, the great river of Southern China, are Che-kiang and Fukien, resembling the Yang-tse provinces in climate and products. Che-kiang has been called a miniature Sechuen, with lower hills forested or cultivated to the summit. The chief port Ningpo, in a rich rice-growing plain, surrounded by mountains, has flourishing cotton mills. Hangchow is an old capital of China. Fukien, also mountainous, produces the finest tea, shipped from Fuchow. Amoy, with a fine harbour, does an immense trade in tea and coolies.

The Si-kiang Basin. The Si [118] rises in the Yunnan Mountains, cutting its way down in gorges and ravines. Together with its two tributaries it drains the three chief valleys of Southern China, which converge on Wuchow, now a treaty port. All the Si basin, which includes part of Yunnan and Kweichow and all Kwangsi and Kwangtung, is mountainous, forming part of the great descent from the Tibetan plateau. Along the river bottoms and

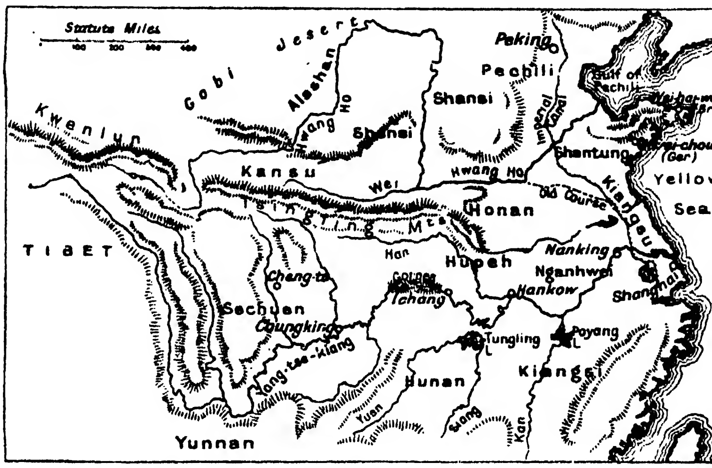
in the fertile plains are grown the usual Central China crops, with others of a tropical character. The forts of Kwangsi produce cinnamon, mace, and other spices. Sugar and indigo and other tropical produce are grown in the fertile maritime province of Kwangtung. Canton is the commercial centre of Southern China. The neighbouring island of Hong Kong is an important pivot of British influence in the Far East.

Manchuria. Manchuria (365,000 sq. miles) is a steppe land backed by mountains. It is drained by the Amur and its tributary the Sungari. The climate is extreme. Its hot summers, monsoon summer rains, and rich black loam make it one of the granaries of the world. Harbin, on the Sungari, mills 1,000,000 lb. of flour a day. The surrounding region is one vast wheatfield. Southern Manchuria is drained by the Liao-ho. The capital is Mukden. The port of Manchuria is Niuchwang. As Manchuria is rich in minerals, furs, and timbers from its forests, Niuchwang is rapidly becoming very important. Port Arthur, formerly Russian, is now Japanese.

Mongolia. The plateau of Mongolia (1,100,000 sq. miles) [118] has an elevation of 3,000 or 4,000 ft. with mountains rising much higher. In the east the Khingan Mountains separate it from Manchuria, intercepting the moist Pacific winds which make Manchuria so fertile. The western margin is formed by the Altai Mountains. Shut off by mountains from moist winds, remote from the sea, and lying high, Mongolia has a dry and extreme climate. The waterless desert of Gobi in the centre of the plateau occupies about a quarter of its area. The rest is steppe, rich or poor according to locality, supporting a scanty population of Mongolian herdsmen and their camels, horses and sheep. The most fertile part lies north of Kalgan, in Pechili, the gate of Mongolia, and extends along the northern margin, which is followed by the high road to Kiakhta, Urga, and Siberia.

Turkestan. This includes the rest of Chinese Central Asia (550,000 sq. miles) outside Tibet. Turkestan is crossed by the lofty Tian-shan Mountains, separating Zungaria and the Ili basin in the north from Kashgaria and the Tarim basin in the south. An explorer has admirably described the region: "If you could get a bird's-eye view of Turkestan you would see a great bare desert, surrounded on three sides by barren mountains. At their bases you would see vivid green spots showing out sharp and distinct like blots of green on a sepia picture." In the western end round Kashgar and Yarkand the cultivation is of greater extent, and more continuous than in the eastern half, where the oases are small and separated from each other by 15 or 20 miles of desert. Both the towns named, and Khotan, further east, are on tributaries of the Tarim. The most important oasis of Zungaria is Kuldja, on the Ili, which flows to Lake Balkash.

Tibet. The plateau of Tibet (740,000 sq. miles) [118] varies in elevation from 9,000 to 17,000 ft., the mountains rising some thousands of feet higher. It is enclosed between the Kwenluns and Himalayas, connected in the west with the Pamirs. In the east a series of little-known



119. BASINS OF THE HWANG-HO AND YANG-TSE-KIANG

ranges, separated by the ravines of the Chinese and Indo-Chinese rivers, form steps in the descent to the Pacific.

Northern Tibet is a desolate region crossed by parallel chains of lofty mountains, inhabited only in the height of summer when wandering herdsmen drive their yaks to the mountain pastures. Settlement is confined to the south, chiefly to the Brahmaputra and its tributary valleys, where barley, peas, and even some stone fruits ripen. The winters are frightful in their inclemency. The keeping of yaks is the chief means of livelihood. The capital is Lhasa, long a forbidden city to Europeans, but occupied by the British in 1904.

Korea. The Korean peninsula (82,000 sq. miles) [118] is everywhere rugged, the northern mountains rising to 8,000 ft. The fertile valleys produce cotton, hemp, and tobacco, but the Koreans do little to develop the considerable agricultural and mineral resources of their country. The capital is Seoul, on the Han, the longest river, at the mouth of which is the chief port, Chemulpo, on the west coast. Fusan, on the Strait of Korea, has a large trade with Japan.

Continued

PARTNERSHIP & SELF-BALANCING LEDGERS

Articles of Partnership. Interest. Division of Profits. Admission of Partner. Dissolution of Firm. Division of Ledger. Balancing by Sections

By J. F. G. PRICE

USE has been made in the preceding pages of the words "partners" and "firm," but the general question of partnership has not hitherto been considered. Sir Frederick Pollock, in his work on the subject, defines partnership as "the relation which subsists between persons who have agreed to share the profits of a business carried on by all or any of them on behalf of all of them," and it is difficult to imagine a more comprehensive definition in few words. The legal relations between partners and the outside world are defined by the Partnership Act, 1890, which codified the law on the subject, and that statute contains the regulations under which partnerships are carried on in the absence of any special agreements between the members of a firm. It is usual, however, in practice for a formal agreement defining their rights and liabilities to be drawn up and executed by partners in a business.

Articles of Partnership. This document is entitled "The Articles of Partnership," and deals, amongst other matters, with the amount of capital to be contributed by each partner, the limit up to which each may draw money from the business on account of his share of the profits, the way profits and losses are to be divided, the question whether interest is to be allowed on the capital introduced or charged on the amounts withdrawn, and the method of arriving at a partner's share of the property in the event of dissolution of the partnership. The manner in which these matters are dealt with varies in different firms, and is a matter which concerns the partners only.

The principal points of difference between the accounts of single traders and partnership are three in number:

1. Each partner has a separate capital account, which is divided into (*a*) capital account; and (*b*) drawings account;
2. Interest on drawings and capital;
3. Division of profits and losses.

There is no hard and fast rule for any of these matters; they are the subject of agreement between the partners themselves.

Separate Capital Accounts. A separate account for each partner is absolutely necessary, as each individual member of a firm is entitled to his own share of the partnership property and no more. The amounts contributed by the partners are in the majority of cases unequal, and it would clearly be inequitable to amalgamate the capitals and give each partner equal rights irrespective of the amount he had brought in or of the work he was to perform. The sum contributed by each partner is therefore debited to cash and credited to him on a separate capital account opened in his name. If a partner should bring into the business any property other than cash, an account is opened and debited with such property, the partner being credited with the value as agreed with the other members of the firm.

It is expedient also to have a separate account for recording the drawings of the partners from the business. The amounts drawn may be numerous, and it is very undesirable to have a large number of small items of cash and goods debited to the capital account proper. As already explained, when a partner draws cash on account of his share of the profits he is debited with the amount, cash being credited. At the end of the financial year, when the accounts are balanced, his share of the profits is ascertained in accordance with the provisions of the partnership articles, and he is credited on his drawing account with the amount. The excess of his share over his drawings is then transferred to the credit of his capital account.

Interest on Capital and Drawings. The question of interest is one entirely within the discretion of the partners when settling the terms of the partnership. In the absence of any arrangement to the contrary interest is not allowed, and it is therefore usual, where capitals are unequal and profits are not shared in proportion to the respective capitals, to stipulate that interest at an agreed rate, usually five per cent., shall be charged to the business for the use of the money and credited to each partner according to the amount of his capital. On the other hand, it is frequently arranged that interest shall be charged against the partners on their drawings, this, of course, forming a credit to the business. The entries necessary to record these charges are (1) a debit to the profit and loss account and a credit to each partner on his drawings account of the amount of the interest on his capital, and (2) a debit to each drawing account and a credit to profit and loss of the amount of the interest on the drawings, this being calculated from the dates on which the drawings take place to the date up to which the accounts are prepared. It may be pointed out that when profits are divided in proportion to the partners' capitals there is no object in charging interest on capital, as the net result will be the same as if no charge were made.

Division of Profits. The manner in which the profits and losses of the business are to be shared depends, as a rule, upon two things: firstly, the amount of each partner's capital; secondly, upon the share which each

takes in the management of the concern. It sometimes happens that a considerably greater amount of work is done by one partner than by another, and this is equalised by the working partner being allowed either a partner's salary or else a larger share of the profits than he would be entitled to having regard to the amount of his capital.

In order to show clearly the working of the drawings and capital accounts a specific case will be considered. Grey and Green are partners with capitals of £3,000 and £1,000 respectively. The business is managed by Green, for which he is allowed a salary of £200 per annum. Profits are shared in proportion to their capitals, interest at 5 per cent. being allowed on the latter and charged at the same rate on drawings. Grey's drawings were £50 on 31st March, £75 on 30th June, and £40 on 30th September. Green's only drawing, with the exception of his salary, which he received quarterly, was £30 on 30th June. The profits of the business, after charging and allowing interest in the profit and loss account, was £600. [See Tables below.]

In preparing the balance-sheet of a firm it is usual to show the capital accounts of the partners in detail. The capital accounts of Grey and Green would therefore appear in their balance-sheet:

LIABILITIES

Sundry Creditors, viz. :						
On Bills Payable ..	685	7	0			
On Open Accounts ..	1,819	15	6	2,505	2	6
Capital Accounts :						
Grey balance, Jan. 1st	3,000	0	0			
Add Interest	150	0	0			
Share of Profits ..	450	0	0			
	3,600	0	0			
Less Drawings and Interest	169	5	0	3,430	15	0
Green balance, Jan. 1st	1,000	0	0			
Add Interest	50	0	0			
Share of Profits ..	150	0	0			
	1,200	0	0			
Less Drawings and Interest	30	15	0	,169	5	0
				£7,105	2	6

Admission of a Partner. From a variety of causes, such as retirement of a partner, increased business, or want of further capital, a new partner is frequently introduced to a firm. The terms upon which he is admited are matters for arrangement, and usually include the investment by him of a fixed sum in the business and

GREY'S DRAWINGS ACCOUNT

Dr.										Cr.
Mar. 31	To Cash	50	0	0	Dec. 31	By Interest on Capital ..	150	0	0	
June 30	,, Cash	75	0	0	,,	,, Profit and Loss Account, being ¾ of profits	450	0	0	
Sept. 30	,, Cash	40	0	0						
Dec. 31	,, Interest on Drawings	4	5	0						
,,	,, Transfer to Capital a/c	430	15	0						
		£600	0	0			£600	0	0	

GREY'S CAPITAL ACCOUNT

Dr.				Cr.		
			Jan. 1	By Cash	3,000	0 0
			Dec. 31	,, Transfer from Drawings Account ..	430	15 0

GREEN'S DRAWINGS ACCOUNT

Dr.										Cr.
Mar. 31	To Cash	50	0	0	Dec. 31	By Salary as Managing Partner	200	0	0	
June 30	,, Cash	80	0	0	,,	,, Interest on Capital ..	50	0	0	
Sept. 30	,, Cash	50	0	0	,,	,, Share of Profit	150	0	0	
Dec. 31	,, Cash	50	0	0						
,,	,, Interest on £30 drawings		15	0						
,,	,, Transfer to Capital a/c	169	5	0						
		£400	0	0			£400	0	0	

GREEN'S CAPITAL ACCOUNT

Dr.				Cr.		
			Jan. 1	By Cash	1,000	0 0
			Dec. 31	,, Transfer from Drawings Account ..	169	5 0

the payment of a premium to the existing partners. The premium is usually regarded as being in respect of the goodwill of the business, and as it frequently happens that there is no account in the books representing that asset, and it has not been necessary hitherto to arrive at the value of it, the price to be paid in this respect is generally fixed upon the basis of so many years' purchase of the annual profits. Two years' purchase is a very usual price, but it may, of course, be either more or less according to the nature of the business.

The premium may be dealt with in two or three different ways. The cash the new partner introduces as his capital will be debited to cash and credited to his capital account. The premium may perhaps be paid to the old partners direct and not come into the new firm's books at all, or it may be paid into the firm's bank account and credited to the old partners in such proportion as may be agreed between them. It is sometimes arranged that instead of a payment being made by the incoming partner a goodwill account is opened and debited with an agreed amount which is credited to the partners in proportion to their shares in the business.

Dissolution of Partnership. In the absence of any agreement to the contrary, a partnership is indefinite as to its duration, but it is automatically dissolved upon the happening of certain events, two of which are the death or bankruptcy of a partner. It is not unusual for the articles of partnership to provide that upon the death of a partner his share in the business is to be calculated upon a certain basis in order to avoid the necessity of preparing a balance-sheet in the middle of a trading period. One method is to take his capital as at the date of the last balance-sheet and allow the addition of profits at the rate of the average for the three preceding years, providing also for the valuation of the goodwill. It is sometimes further provided, in order that the business shall not be crippled by the sudden withdrawal of a large amount of capital, that payment to a deceased partner's representative shall be made by instalments. In other cases provision is made for such a contingency by an insurance of the lives of the partners being effected at the cost of the firm, which will, of course, receive the sum insured in the event of the death and use the money to pay out the deceased partner's capital.

Final Winding-up. The kind of dissolution, however, which requires further explanation is the complete winding-up of the firm owing either to failure or to the period for which it was entered into having terminated, or to general agreement amongst the partners to discontinue business. In any of these events it is necessary to realise the assets and pay to each partner the amount due to him in respect of his capital. The first step to be taken is to prepare a balance-sheet as at the date of dissolution. An account called the realisation account is then created, and the values of the assets as appearing in the books are transferred to its debit, the various assets accounts being closed by being credited by the amounts so transferred. As the realisation proceeds, cash account will be debited, and the realisation account credited with the sums received.

When the assets are sold the balance of the realisation account will represent the gain or loss on realisation, probably the latter, for assets seldom realise their book values. This balance must be treated in the same manner as if it were the balance of the profit and loss account. If it represents a gain, it will be transferred to the credit of the partners and increase the amount of their capitals, while, on the other hand, if, as is probable, there is a loss, it will be transferred to the debit of the partners and reduce their capitals. Any expenses of realisation will also be debited to the realisation account as they are paid, while cash will be credited with the payments as well as with payments to the creditors. The result will be a balance on the cash account representing the excess of the proceeds of the sale of the assets over the liabilities and the expenses of winding up. As all the assets have been sold and their proceeds received in cash, the balance of the cash account will equal the aggregate of the balances on the partners' capital accounts after the latter have been debited with the loss or credited with the gain on realisation.

Self-balancing Ledgers. We have so far assumed that one ledger only has been used in the businesses with which we have dealt, but it will have been obvious to the observant reader that in undertakings where a large business is carried on the debtors and creditors must be too numerous to allow of all their accounts being kept in one book. Where this is the case, it is necessary to divide the ledger into sections, each set apart for a particular class of transactions. It must be remembered that where separate books are used the ledger as a whole consists of all the different sections, and if it is desired to prove the books at any time by means of a trial balance, it will be necessary to extract the balances of all the accounts in every ledger before agreement can be obtained.

This, in a business where there are hundreds of debtors—and there are many such—is a work of considerable magnitude; and if when all the balances have been extracted the totals do not agree, the bookkeeper is at a loss to know in which ledger to look for the error. In order to obviate the necessity of searching through all the ledgers to find a difference which may exist in only one of them, a method has been devised by which it is possible to localise errors and thus restrict the search to the particular section indicated as being that in which the error has arisen. The system is variously known as sectional balancing, self-balancing ledgers, and balancing by totals, but, subject to very slight modifications, these terms refer to the same system whichever name is employed.

Sectional Principle. The underlying principle is that each ledger must contain *in itself* a complete double entry of all the transactions recorded in it. This is, of course, always the case where only one ledger is used, but when,

owing to the increase in the number of accounts, it becomes necessary to have more than one ledger, it is highly probable that while the debit side of a transaction may be posted to one ledger the credit side will be posted to another. Thus, in the case of a sale of goods the debit to the customer would be made in the sold ledger, while the credit to the goods or sales account would be made in the general ledger. If nothing further were done, it would be necessary, in order to obtain a trial balance, to extract the balances of all the ledgers, but if each ledger is so arranged that the total of its debits is equal to the total of its credits, it will be possible at any time to extract a trial balance of each ledger separately, and so ascertain that the work of posting has been correctly performed. This may sound somewhat like duplicating work, but it is not so in fact, and the gain is so enormous in a large concern that the slight amount of extra trouble is fully compensated for by the result achieved.

The system is only necessary in a business where the ledger is divided. The first division which is made is usually into (1) sold ledger, containing the accounts of the debtors; (2) bought ledger, containing the creditors' accounts, and (3) general ledger, set apart for such accounts as stock, purchases, sales, the various revenue and expenditure accounts, the capital and drawings accounts of the partners, and the assets of the concern, other than book debts. The sold ledger is frequently further divided into sections set apart for town and country debtors, or for portions of the alphabet, and sometimes for both.

Separate Sold Ledgers. It will be sufficient for the purpose of explaining the system to take a case where the sold ledger is divided into town and country ledgers, as the principle applied is the same whatever the number of ledgers. There must be either separate books of first entry for each ledger (and this is the better method where the ledgers are numerous), or the books from which the ledgers are posted—*viz.*, the sales, returns inward, cash and bills receivable books—must be ruled with columns for both ledgers, care being taken to enter the items in the column relating to the ledger in which the customer's account is kept. The postings to the debit of customers of the goods sold to them will be carried out in the usual manner, and the gross

Dr. ADJUSTMENT ACCOUNT IN TOWN SOLD LEDGER Cr.

Jan. 31	To Cash received as per Town column of Cash Book	1,208	1	9	Jan. 1	By Balance b/d, being the total of the balances on the customers' accounts	2,743	16	8
	,, Discount (Cash Book)	24	6	3	Jan. 31	,, Sales as per Town column of Sales Book	1,426	18	2
	,, Returns as per Returns Inward Book, Town col.	42	8	6	Feb. 28	,, do. do.	1,107	5	3
Feb. 28	,, Cash and discount as above..	1,124	5	3	Mar. 31	,, do. do.	1,384	12	6
	,, Bad Debt as per analysis of Journal ..	42	8	11		,, Dishonoured bill as per Journal	27	10	0
Mar. 31	,, Cash and discount ..	1,456	8	1					
	,, Bills Receivable as per Town col. of Bills Receivable Book ..	84	2	6					
	,, Balance c/d, agreeing with aggregate of debtors' balances ..	2,708	1	4					
		£6,690	2	7			£6,690	2	7
					April 1	By Balance b/d	2,708	1	4

Dr. TOWN SOLD LEDGER ADJUSTMENT ACCOUNT IN GENERAL LEDGER Cr.

Jan. 1	To Balance b/f, being total of balances on customers' accounts ..	2,743	16	8	Jan. 31	By Cash received as per Town column of Cash Book	1,208	1	9
Jan. 31	,, Sales as per Sales Book, Town column	1,426	18	2		,, Discount do. do. ..	24	6	3
Feb. 28	,, do. do. ..	1,107	5	3		,, Returns as per Returns Inward Book, Town column	42	8	6
Mar. 31	,, do. do. ..	1,384	12	6	Feb. 28	,, Cash and discount ..	1,124	5	3
	,, Dishonoured bill as per Journal	27	10	0		,, Bad debt as per Journal	42	8	11
					Mar. 31	,, Cash and discount ..	1,456	8	1
						,, Bills receivable as per Town column of Bills Receivable Book ..	84	2	6
						,, Balance c/d, agreeing with total of debtors' balances	2,708	1	4
		£6,690	2	7			£6,690	2	7
April 1	To Balance b/d	2,708	1	4					

total of the sales, both town and country, posted to the credit of the sales account in the general ledger. The cash, bills receivable, discount, and the returns inward—*i.e.*, from customers—will be posted to the credit of the customers' accounts, while the gross totals will be posted to the debit of the respective accounts in the general ledger relating to bills, returns, etc. This would complete the ordinary double entry of the various transactions, and the accuracy of the work could be tested by extracting a trial balance covering all the ledgers. But in order to obtain the desired result of balancing each ledger separately, we must obtain from the books of first entry the totals of the postings made to the debit and credit of customers in the two ledgers respectively. This is done by means of the town and country columns in each book, which are totalled at the end of the month, and the amounts posted to accounts opened at the end of each sold ledger, entitled General Ledger Adjustment Account.

The effect of this operation will be that each sold ledger will balance in itself, for, taking the case of the town ledger, the sales to town customers will have been separately posted to the debit of individuals, while the total of the town column in the sales book will be posted to the credit of the adjustment account. The cash, bills received, and discount, will have been posted to the credit of the customers individually, and the totals of the town columns in the cash and bills receivable books will be posted to the debit of the adjustment account. Returns inward will be posted to the credit of customers, and the total of the town column to the debit of the adjustment account. It will be apparent that if these entries have been correctly made the town ledger will balance in itself, for care has been taken to debit and credit to the adjustment account in total the items that have been credited and debited to the customers separately. It will be necessary to dissect the journal for any items affecting the town ledger in order that the totals may be entered on the adjustment account on the opposite side from that on which they were entered in the case of the customer. These items may consist of dishonoured bills, bad debts, special allowances, etc. The result will be, if the work has been accurately carried out, that the balance of the adjustment account will equal the aggregate of the balances of the other accounts in the ledger—*viz.*, those of the town customers. This balance is carried down at balancing time and shows at a glance the total of the customers' balances then owing.

General Ledger Adjustment. In order that the balancing of the books as a whole may be preserved, an adjustment account is raised in the general ledger for each of the other ledgers, and the entries made on these accounts will naturally be the reverse of those made in the adjustment accounts in those ledgers. In order that the working of the system may be thoroughly understood, specimens of the adjustment accounts in a town sold ledger and in a general ledger respectively are shown on previous page.

In the case of a small business, with only three ledgers—*viz.*, sold, bought, and general ledgers—it might be more convenient to prepare monthly summaries by analysing or dissecting the books of first entry and showing in the form of an account the totals of the postings to the three ledgers. Thus, in the case of the bought ledger, the credit side of the cash book would be analysed, and the amounts which had been posted to the debit of persons whose accounts were kept in the bought ledger would be extracted, totalled, and entered on the credit side of the summary. The purchases book would give the total of the postings to their credit, and this would be entered on the debit side of the summary. Any returns outward would be taken from the returns book, and as these would have been posted in detail to the debit of the sellers, the total would be entered on the credit side of the summary. Any bills given to the creditors which have been posted to their debit would be entered in total on the credit side of the summary, which would then appear in this form :

Dr.	SUMMARY OF BOUGHT LEDGER									Cr.
Jan. 1	To Balance b/f. being total of the balances of the creditors' accounts	283	5	4	Jan. 31	By Cash paid to creditors, as per analysis of Cash Book	148	6	9	
Jan. 31	„ Purchases as per Purchases Book	195	6	0		„ Discount allowed by creditors	5	6	0	
						„ Returns outward ..	18	10	0	
						„ Bills payable	50	0	0	
						„ Balance c/d, agreeing with total of creditors' balances ..	256	8	7	
		£478	11	4			£478	11	4	
Feb. 1	To balance b/d	256	8	7						

Continued

SMITHS' WORK

Smiths' Tools and their Use. Forging Iron and Steel. Drawing Down, Fullering, Upsetting, Bending, Welding, Punching, and Drifting

continued from page 2867

By JOSEPH G. HORNER

WE now go into the smithy, and observe the methods practised there. We find conditions of an entirely different character from those which exist in the foundry—conditions which are inseparable from the difference in pouring molten, and in shaping plastic metal. The nearest approach ever made to the molten state of metal in the smithy is when a welding heat is taken on iron, at which the surface becomes partially fused, so that isolated globules drop off as the bar is taken from the fire. If wrought iron were to be fused like cast iron, it would become partially carbonised, and so lose the pasty condition which renders it of so much value. On the other hand, cast iron could not be hammered, but would at a red heat become absolutely fragile and rotten. These differences explain the cardinal differences in the practice of the two departments.

Wrought iron and mild steel when heated to temperatures corresponding with a full red or white heat become pasty and plastic, and in this state will endure any amount of hammering and reduction in size, or of bending and rolling; while at a full or dazzling white heat they can be welded. Their malleability and ductility enable them to endure the most severe treatment without loss of strength, and, in fact, such work done upon them, provided proper precautions are observed, increases their strength, without reduction in ductility and malleability. But before proceeding farther it is necessary to point out the important differences between iron and steel, with the corresponding differences in the methods of working them.

Differences in Working Iron and Steel. Chemically, there is no distinction worth mentioning between wrought iron and the mild or low carbon steel that is used for forgings. But there are great differences in their physical characteristics, and in the methods of working them. Iron has very pronounced fibre, steel has none, except a negligible amount that is developed in rolling. Iron has some four tons per square inch more of strength along the direction of the fibres than across them. Steel is equally strong in any direction. Iron is fibrous because it has been piled, welded, and rolled in layers. Steel is homogeneous because it has been melted and poured previous to being rolled. Because iron is fibrous, it welds better than steel. On the other hand, its bundles of fibres prevent it from being upset or enlarged so readily as steel. Steel is stronger than iron, and more ductile, and, therefore, it can be bent more, and can be elongated, drifted, and reduced in section more before it fractures than iron. The same steel can be both cast and forged; not so wrought iron.

Smiths' Tools. Such being the materials in which the smith works, we find their characteristics reflected in the tools and appliances employed by him. They are hammers, and numerous hammer-like tools, in which moulding or shaping processes are combined. Fullering tools, flatters, swages, punches, drifts, are the predominant forms. The appliances are also swages and swage blocks, bending blocks, dies, and allied forms, in which metal is coerced by impact or pressure into any desired shapes. The leading forms are shown in the group **126–133**.

The actual cutting tools are represented by the *cold* and *hot setts*, or *chisels* [**124** and **125**], variants on these being the *hollow setts*, or *gouges*, having edges curved instead of straight. The group of tools in **126** to **133** all mould, but do not cut. Fig. **126** is a *fuller*, or *fullering tool*, straight crossways, used for rapid reduction of stock; **127** is a *curved* fuller, for working close up to a boss; **128** forms isolated spherical depressions; **129** is an *anvil fuller*, used in opposition to the fullering tool [**126**]. After a surface intended to be flat has been fullered, it is smoothed with a *flatter*, or *sett hammer* [**130** and **131**]. If the object be required of circular form, it is finished—and often fullered down also—between *top* and *bottom swages* [**132** and **133**], the latter being *anvil swages*. To avoid having top and bottom tools separate is the object of the *spring tools* [**134–137**], in which the two are combined, and united by spring handles that permit of opening and closing. Fig. **134** will be recognised as a pair of fullers, **135** as top and bottom swages, **136** as three pairs of different sizes, between which in rapid succession a round bar is reduced, and **137** as a single pair with the hole at right angles to that in **135**. In the *swage block* [**138**], which is in incessant use, the edges are simply an aggregation of bottom swages of varying shapes and sizes, while the holes with which it is pierced form fulcra for use in bending bars. The *anvil* [**139**] is simply an appliance on which work can be fullered, flattened, and bent, the *beak* being much used for turning eyes, while bottom swages, and the cutter, or the anvil fuller [**129**], are inserted in the hole.

Hence no tools used by smiths, except those employed for the actual severance of bars and work, are cutting tools. In this respect the work of the smithy stands apart from other trades. If a bar has to be reduced, it is not done by cutting, but by *fullering*. All finishing processes are effected with tools that are destitute of sharp edges. Fullers, swages, even flatters, have slight convexity on their edges, so that no keen angles are left anywhere on the work, and

there is no severance of fibre, but only a moulding process.

Materials and Tongs. So also the forms in which the materials are rolled are very simple and very few. They comprise round rods and bars of square and rectangular sections, and from these almost all conceivable shapes are produced by processes which are in their essentials few and simple. These forms have their counterparts in the tongs by which they are handled [**140** to **151**]. Figs. **140** and **141** are both *flat-bit tongs*, for flat bars. The first are *close*, the second *open mouth*—meaning, that the former are used for thinner, the latter for thicker bars. Fig. **142** is the *crook-bit tongs*, which hold a long bar parallel with the handles, secured by the crook or lip on one jaw. Fig **143** is the *hoop tongs*, for holding hoops or bars at right angles with the handles. Fig. **144** is a form of *pliers* for picking up light lengths of rod, or holding punches and drifts, and **145** shows the *pincer tongs*. Into the hollow space the heads of bolts, collars, and extensions on work may enter. The jaws are often notched, or veed. Fig. **146** represents the *hammer tongs*, which pick up work having holes, the points entering into the holes; **147** is a form of *pliers*, the jaws being often veed as in **148**, and the space behind serving the same purpose as that in **146**. Fig. **149** is the *hollow-bit tongs*, for gripping circular bars; and **150** and **151** are *flat-bit* tongs of two kinds, with edges turned up to retain bars sideways.

All these tongs are handled like **140** and **141**, though the handles are not completed in the rest of the illustrations. As the grip of the smith would not be strong enough to hold them in close contact around the work, they are tightened by a ring, A [**140**], driven over the handles with a hammer. The ring is termed the *reins*, or the *coupler*.

Forging Operations. The processes of forging may be classified broadly as follow: Drawing down, upsetting, bending, punching, welding, all of which we shall consider in turn.

Drawing Down. As from a piece of bar or rod of uniform dimensions forgings have to be made with cross sections of different sizes, there are two methods of producing such differences. One is by reduction from a larger to a smaller (*drawing down*), the other by enlargement from a smaller portion (*upsetting*). The only alternative to these is welding pieces of different dimensions together, but this method is reserved for some rather unusual cases, to be noticed presently.

Drawing down is the operation which, when conditions are favourable to it, is universally adopted. The principal condition is generally a length not too great to be reduced conveniently. For example, while **152** and **153** are suitable cases for reduction, the relative lengths of the sections have to be considered. Work is on the border line when there is a much greater length, B, to be drawn down from the bar of diameter A [**152**]. If the portion B were, say, several feet in length, the method of drawing down would be very seldom adopted, because of the amount of work it would entail, though the forging would be none the worse, but better for hammering. Fig. **153** is an excellent case for drawing down.

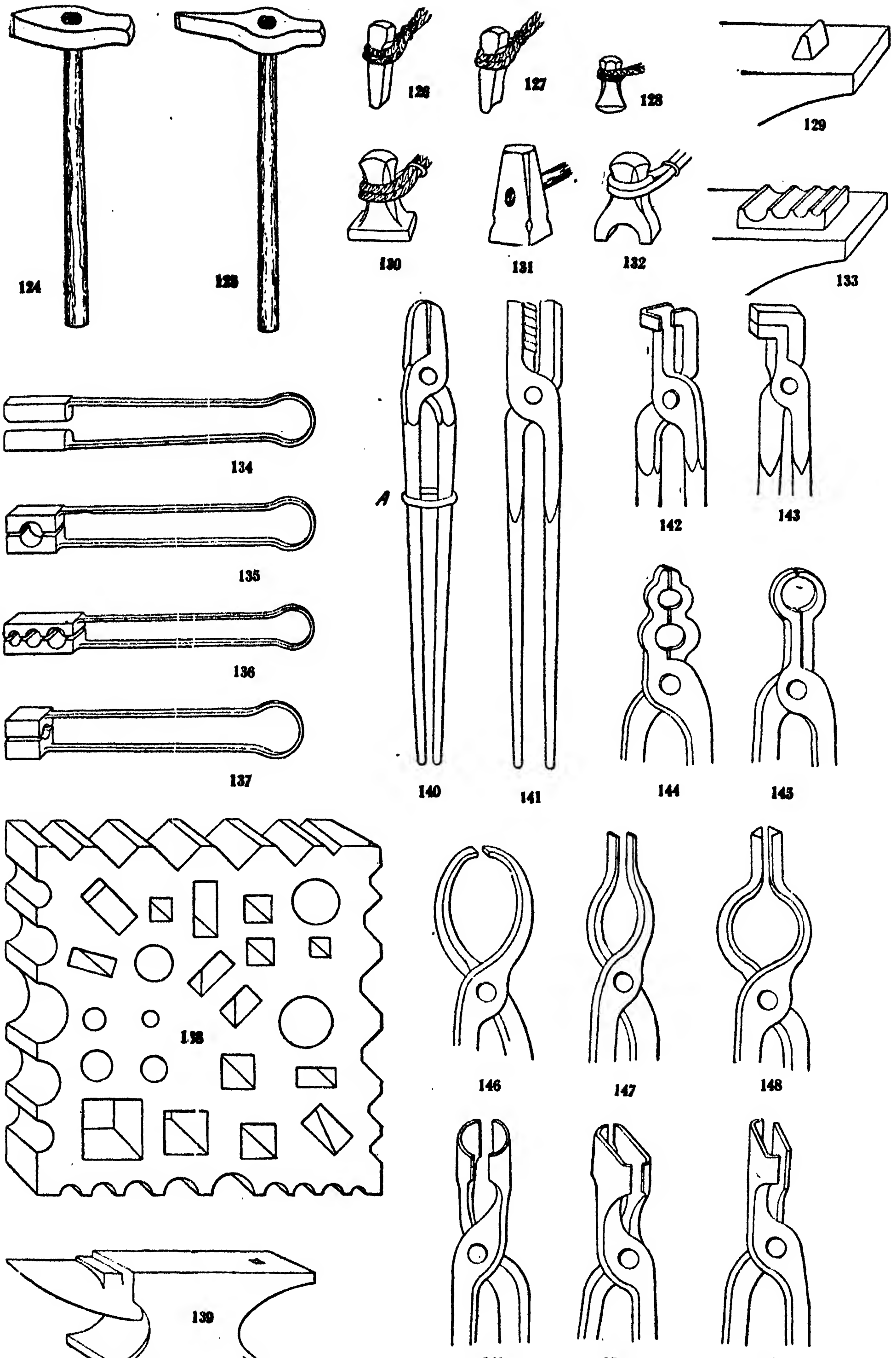
Power Hammer Work. But a most important governing condition which often decides the smith to draw down a greater proportionate length than **152**, is the possession of a power hammer. There is a vast difference in reducing laboriously on the anvil by fullering tools and sledge, and doing the same work under a steam or drop hammer with a falling weight measured in tons. Where such are available, the smiths use up any odd chunks of metal and reduce them how they choose, often drawing down ends from 3-in. or 4-in. pieces of bars, to 1 in. or less at a single heat. The work is easy and simple, being confined to turning the pieces about between the hammer blows. But, obviously, there is a limit to this. Suppose that an enlarged end, 6 in. long has to terminate a rod 20 ft. long, it would be practically impossible to reduce such a length, or anything approaching it, so that drawing down is then out of the question.

Another governing condition is the shape of the enlarged end. In **152** and **153** there is no difference in the shapes of the larger and smaller parts. There are differences in **154**, **155**, and **156**; and **154** is on the border line. Its flat foot A, and bosses B and C, are not so very greatly different in section but that they might be formed by upsetting, nor are the lengths of the stems so great but that they may easily be formed by drawing down from bar of the size of B, C, with a little upsetting for A. But when there is much difference, as, say, in a tie-rod with eyes [**155**], or a valve bridle [**156**], the making of the eyes has to be considered as of more importance than the plain rod. As a general rule, with very few exceptions, such eyes are made distinct and separate from their rods, and welded on to them. But this also depends on proportions, materials used, and on facilities afforded by power appliances; **156** would, if made in steel in stamps, be made by drawing down.

If eyes are of small diameter, and the rod short, then they are made from one piece, the rod being drawn down. If the eye is large, and the rod short, the job is on the border line where different methods might be selected. If the rod be very long, say several feet, then a separate plain rod is taken for that, and welded to the eye previously forged separately.

Another condition is that of work having arms standing out at right, or nearly right, angles. To draw down such pieces, the bar must be slit, forked, and opened out. This is often done, but, generally, welding is preferable. The foregoing are typical of many groups of work that occur in the smithy.

Iron and Steel. Whether a forging be made in iron or in steel must often determine the preference for one method over another. It applies particularly to welding. Welds in iron are, with the exercise of reasonable care, as safe as solid metal. Those in steel are not so reliable, and the risks increase rapidly with higher



SMITHS' TOOLS

124. Cold sett **125.** Hot sett **126.** Fuller **127.** Curved fuller **128.** Boss fuller **129.** Anvil fuller **130.** Flatter **131.** Sett hammer **132.** Top swage **133.** Anvil swage **134.** Spring fullers **135–137.** Spring swages **138.** Swage block **139.** Anvil **140.** Close-mouth flat-bit tongs **141.** Open-mouth flat-bit tongs **142.** Crook-bit tongs **143.** Hoop tongs **144.** Pliers **145.** Pincer tongs **146.** Hammer tongs **147, 148.** Pliers **149.** Hollow-bit tongs **150, 151.** Flat-bit tongs

contents of carbon. Many engineers will not have steel welds at all, or if they do, they only allow them a moderate percentage of the strength of the solid bar. The fibrous character of iron is eminently favourable to welding, but from other points of view it has its drawbacks, some of which we must now notice.

If a bar of steel be used for a forging, the smith need take no account of fibre. That is, he can cut it, punch it, and work it to any required shape, knowing well that its strength will be alike in every direction. But in working iron he has to take account of the direction of the fibre of the iron almost as much as the carpenter has to consider the grain of the timber he uses. Failing to do this, there are many forgings, the shape of which is such that they would open out or fracture, through the short fibre, when subjected to working stresses. A hundred examples might be selected, but a common loop, or eye [**155** and **156**], illustrates the idea excellently.

Such eyes, if made in steel, are produced by punching a hole and slightly enlarging it by drifting. But if punched in iron the fibre would be short at A, and the chances are that the eye would open out or fracture at A, and the risk would be the greater because the punching and drifting would have tended to separate the fibres there. The poorer the quality of the iron, too, the greater would be the risk. Such an eye, if made in iron, would have to be produced by bending rod round, and welding. Then the fibre would run round the eye, and would be unbroken and of equal strength everywhere.

Fullering. Drawing down is done by direct hammer blows, which method is, however, suitable only when the reduction is slight in amount. More commonly it is effected by the process termed *fullering*, which effects more rapid reduction by a series of hammer blows dealt by the fullers or tools with convex edges, as in **157**. The result is that the surfaces of the bar are indented with a series of corrugations, being at the same time reduced rapidly in thickness. When the greater part of the reduction has been effected in this way, the ridges are obliterated, and the surface smoothed level, and finished with flatters [**160**].

The foregoing is merely a bald statement of the work of fullering, which varies in different kinds of objects. When a piece of bar of rectangular section is being thus reduced, the smith turns it about from faces to edges alternately, so effecting reductions at right angles, instead of working on faces first and edges afterwards.

Tools for Fullering. When work is being fullered on the anvil, the bottom fuller may be just like the top one [**157**], in which case the reduction is effected on opposite faces of the bar. The bottom one is then generally an *anvil fuller* [**129**], so called because it is fitted in the hole in the anvil similarly to the anvil stake. Often, however, the work is laid directly on the anvil, and fullered on the top face only [**158**]. This would always be done when one face of the forging was flat—that is, without a boss or other projection standing up therefrom.

In drawing down an object of circular section, the fullers are seldom used, but the hammers only, from start to finish, because le s labour is required to reduce such a section than one having flats. Where a power hammer is available, reduction is easily effected between the flat faces of the tup and anvil, turning the work about between each two or three blows [**159**] to present fresh edges, and so effect the reduction uniformly. Very often these reductions are effected in dies, to which we shall come presently.

Fig. **160** illustrates the finishing of a surface previously fullered, with a flatter, or sett hammer, on the anvil; **161** shows a circular rod being finished between top and bottom swages, also on the anvil, for which spring swages [**134** to **137**] might alternatively be employed, or the edge of the swage block [**138**] and a top swage. In **162** another method of fullering under the steam hammer is shown, a round rod being used to effect the fullering, struck by the tup.

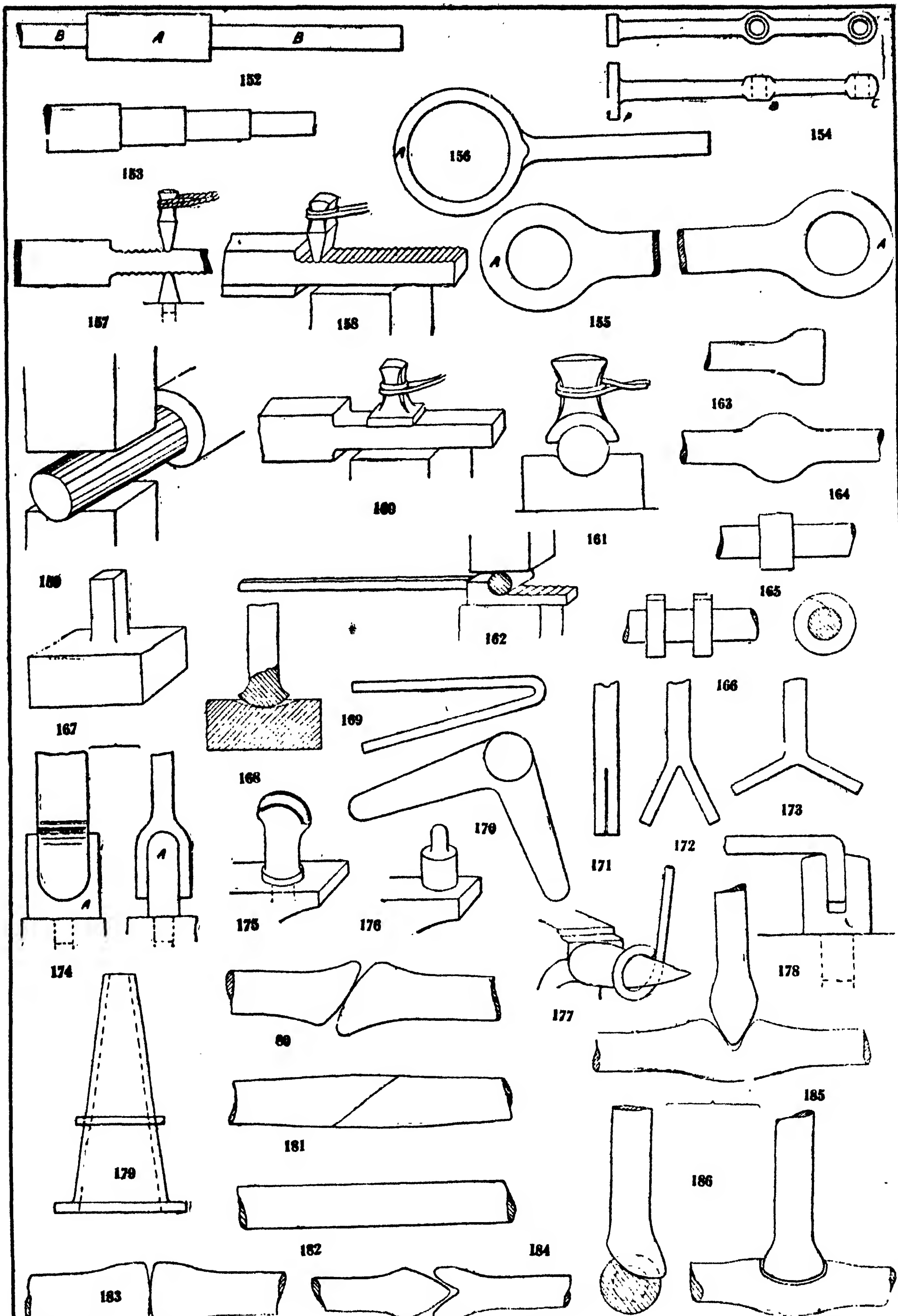
Upsetting. This is the general alternative to drawing down, and the conditions suitable for its employment are the reverse of those which we have stated as being favourable to drawing down. If a small enlargement be required at the end or central portions of a bar, and not of excessive length, as at BC [**154**], that is a case for upsetting. It is not a desirable process in wrought iron, because it tends to open the fibres.

The term expresses literally the nature of the operation. A *short heat*, or localised heat, is taken only, over the part to be enlarged, and the metal is thrust out laterally [**163** and **164**]—that is, upset by blows delivered on the end of the bar. These are given by *up-ending* the bar on the anvil, or on the floor-plate, and bumping it up and down a number of times; or, if too massive to be handled, it is laid horizontally on the anvil, and blows are delivered on the end by a swinging monkey. This is suspended from a beam by a rope, and drawn back by helpers at another rope, and let go to make impact against the end of the bar.

Obviously, the amount of lateral extension possible is very limited. An extension of 1 in. bar to 2 in. over a length of 2 in. or 3 in. would be a very considerable quantity of upsetting to accomplish. So that this device is seldom adopted, excepting on short lengths, and then generally when the original size of bar is of good length—say 2 ft. or upwards. If shorter than this, drawing down is preferable.

If much enlargement be necessary, then the fibres should be closed and consolidated afterwards by hammering them at a welding heat. In iron it is generally preferable to resort to welding.

An upset portion is always of rather irregular shape, and correction is necessary, if definite shapes are required. Thus the collar [**165**] can be produced from an upset mass by subsequent swaging. But if two collars were required [**166**] the work would be simplified by welding the two on as rings, as shown, rather than by upsetting



TOOLS AND OPERATIONS

152, 153. Cases suitable for drawing down 154-156. Cases in which drawing down is an alternative 157, 158. Fullering 159. Drawing down under a power hammer 160. Finishing with the flatter 161. Finishing between swages 162. Fullering with a round rod 163, 164. Examples of upsetting 165. Collar produced from an upset portion 166. Collars welded on bar 167, 168. Article formed by welding preferably to upsetting 169. Bar easily bent 170. Lever bent with difficulty 171-174. Stages in the formation of a forked end 175-178. Aids to bending 179. Conical stand for bending rings round 180, 182. The scarf weld 183. The butt weld 184, 185. The vee weld 186. Scarf weld at right angles

and swaging. The article in 167 looks like a job for upsetting, but it is not so. The discrepancy in stem and body is too great. The proper way to make this also is by welding the stem to the body, as in 168.

Bending. This operation is constantly being done, generally alternating with other operations. Some jobs are practically "all bending." It is accomplished in many ways, and, with few exceptions, at a red heat. Some objects cannot be produced by bending, and then welding or some other device, such as stamping, is the alternative.

Bending can be performed properly only when the radius or angle is such that the inner layers of metal are not crumpled, nor the outer ones attenuated. What happens when a bar is bent is that the layers of the inner curve are squeezed into and occupy a shorter distance, and the outer layers are extended and occupy a longer distance. Between the zones of compressed and extended fibres there is a layer—the neutral axis—where the fibres undergo neither change. This, it is well to observe, is the zone on which the actual dimensions for curved work have to be measured.

Limitations of Bending. Now, it is easy to see that iron and steel are only capable of moderate compression and extension; steel more than iron, but limits are set to both. The greater the distance between the neutral axis and the extreme edges, the harder will be the work of bending, and the greater the amount of crumpling and stretching. Thus the bar [169] would be easily bent to an acute angle as shown, but the broad, flat web of the bell crank lever [170] would be very difficult to bend, and should preferably be formed by welding two webs at right angles.

Bending is often preceded by division of a bar. Thus, 171 to 173 represent three successive preliminary stages in the making of a forked end. In 171 the bar to be used is divided from opposite faces with the hot sett [125]; in 172 it has been partly opened out; in 173 spread out more, but without nicking of the fibre at the root. Then in 174 it is finished by hammering round the form A held in the anvil (or other equivalent fastening). Other examples of aids to bending on the anvil are 175, a block for short radii; 176, a block for turning complete rings, done alternatively on the anvil beak [177]; and a block [178] for bending bars to angles; 179 is the conical stand for bending rings.

The methods of bending are therefore varied. Bars are bent by pulling them round mandrels with the tongs or the hands, or by hammering, or pulling and hammering alternately. Mandrels are any loose rods selected of the size required for a given radius, and are often held in the hand. Often they are specially made to fit in the hole of the anvil. The holes in the swage block serve as leverages for bending bars inserted therein. The anvil beak is utilised as a mandrel. Many bending blocks are made for special jobs, used apart from the power hammers, or with them. The shop conical mandrel stand is used for bending large radii and rings.

Welding. The ability to unite two pieces of wrought iron or steel at a white heat is work peculiar to the smithy. This property is invaluable both from constructive and economical points of view. It would be extremely difficult to manufacture some classes of objects without this aid; it would increase the cost greatly in a larger number of cases.

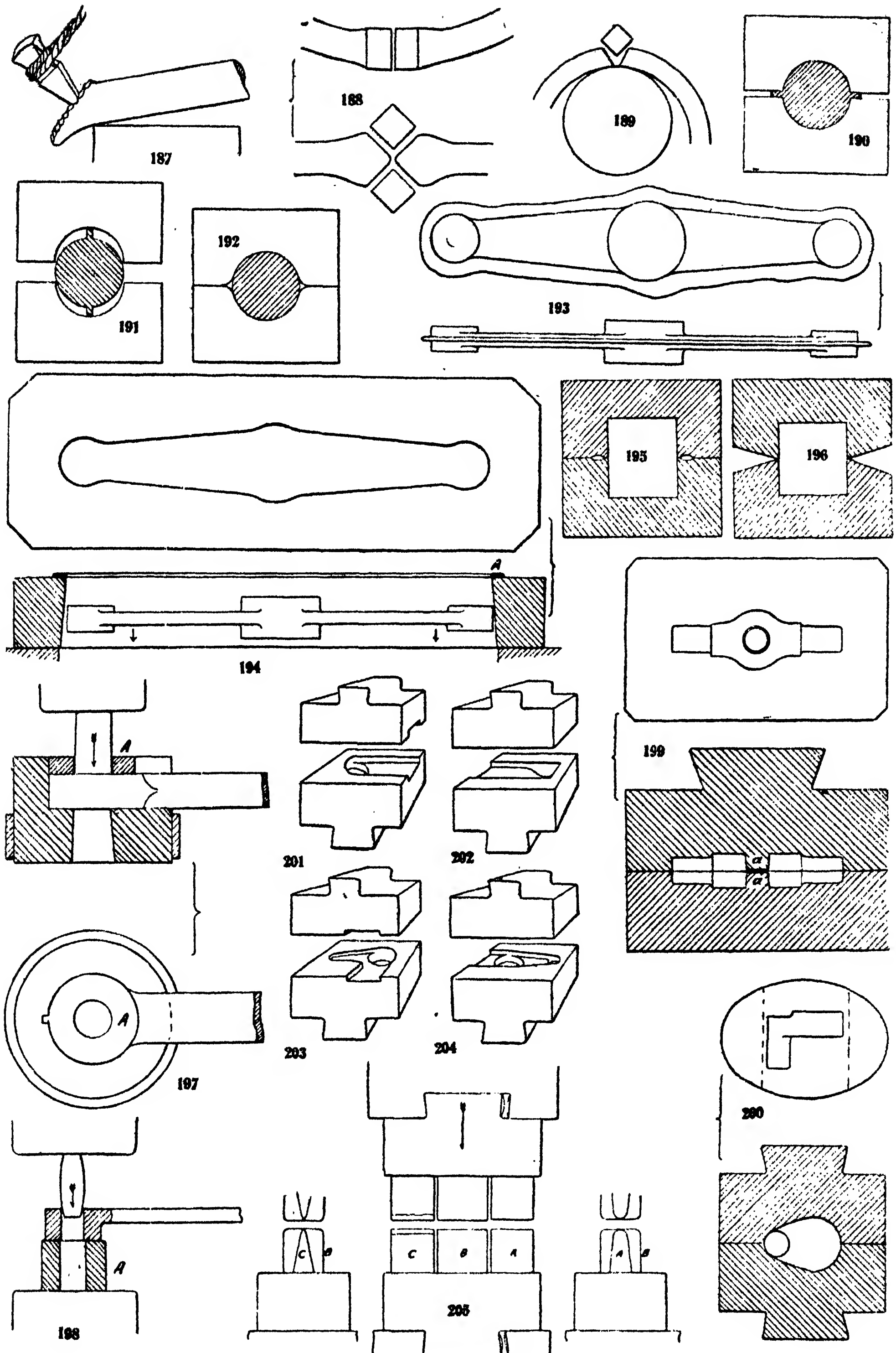
The difference between welding and soldering, or brazing, the operations which it most resembles, are that these are effected by a cementing material applied between cold surfaces, while welding is an autogenous process in which surfaces are united by impact or pressure while in a semi-fused condition. A good weld is as strong as the unwelded portions.

The forms of welds are varied with the shapes and relations of the parts to be united. They include the *scarfed* form, the best and most common; the *butt*, least satisfactory unless the surfaces united are of good area; the *vee*, and its allied form, the *glut*. In any weld joint the expulsion of the scale is an essential object, and so we find that certain precautions are taken in making the joints, the reasons for which would not be understood by a beginner.

The Scarf Joint. Fig. 180 shows two ends prepared by scarfing for this form of weld. There are three points to notice—the length of the scarfing, the upsetting, and the convexity of the opposed faces. The length is properly about that shown. A shorter scarf gives less holding area, and in a much longer one there is risk of some of the scale remaining entangled in the joint. The upsetting, or enlargement, is imparted in order to give excess of metal over that of the body of the bar. If this were not done the welded part would be smaller when finished than the rest of the bar, and therefore weakened and unsightly. The convexity is imparted to cause any scale present to be squeezed out by the act of welding. Fig. 181 shows the appearance of the joint after it has been closed, and 182 after it has been swaged and finished neatly.

The Butt Weld. This [183] is, as its name implies, a weld in which two surfaces, either quite flat or slightly convex, are brought into opposition and welded. The process when applied to flat surfaces is often termed *dabbing on*. Bosses are welded thus to plated portions to avoid the labour of drawing down the plated part from the boss. Rods and bars are welded at right and other angles by this form of joint, alternatively to the vee and scarf. The same precautions are taken as in making the ordinary scarfed joint.

The Vee Weld. A vee weld [184] may be regarded as a double scarfed one. Its value lies chiefly in making joints at right or other angles rather than in straight lines. It is considered more reliable than a plain scarf, but is not so quickly made, and is not employed to so great an extent. The upsetting and the convexity of the meeting faces are embodied as in the scarfed form. Fig. 184 joins two bars in line, 185 two at right angles; 186 is a common alternative showing the preparation for one form of scarf weld at right angles, where both the



SMITHS' DIES, ETC.

187. Upsetting an end by fullering **188, 189.** Glut welds **190-192.** Formation and obliteration of fin **193.** Forging with fin **194.** Stripping die for same **195, 196.** Provisions in dies for receiving fin **197.** Punching in dies **198.** Drifting **199.** Punches in dies **200.** Dies that fit by dovetails **201-204.** Dies for bossed ends **205.** The Brett system of roughing out

upsetting and convexity are embodied; **187** shows the usual way in which an end is upset for a scarfed joint. The bar is held at an angle across the edge of the anvil and spread out by blows on the fullering tool. Afterwards it is smoothed by hammer blows.

The Glut Weld. A glut weld [**188** and **189**] is a variety of the vee. It is, however, employed more by boilermakers than by smiths. The latter use it chiefly in welding up rings of rectangular cross section, but it is alternative to a scarfed joint.

Precautions. The precautions to be taken in welding are few in number but very essential, as follow.

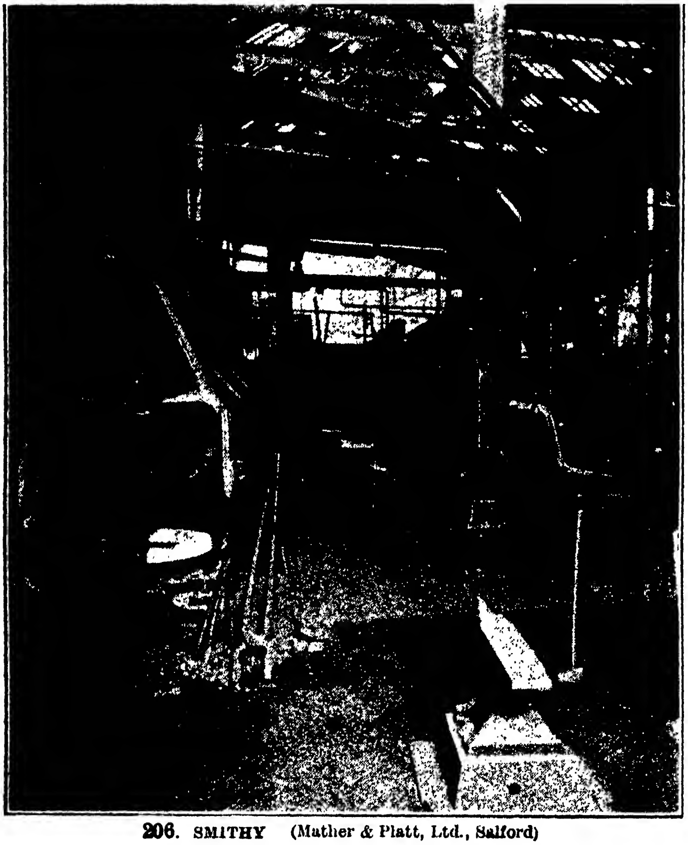
The heat for welding must be graded according to the material. Iron may be, and is generally, raised to a heat so white that globules of metal drop from it as it is taken from the fire to the anvil. But such a temperature would ruin steel by producing burning or oxidation. A full white heat is the limit for steel. There must be no scale (oxide) or dirt present on the faces to be united. Therefore, the heat must be taken in a hollow fire away from contact with coal. Sand or other flux is dusted on the metal in the fire before it is removed to the anvil. A file is often brought into requisition to remove scale. Sand is dusted on the work at the anvil, and over the anvil on which it is laid to be welded. All these precautions are more essential with steel than with iron.

The closing of the weld must be done *quickly*, and with *light* rather than heavy blows. Generally the hand hammer only is used, the sledge following after, or being reserved only for massive work. If the weld be not closed in about the first eight or ten seconds, no amount of subsequent hammering will make it good, because the necessary heat will be absent. A weld can be made only when the surfaces in contact are nearly at fusing point. Afterwards the jointed portion is finished neatly at leisure.

Punching. A good deal of forging involves the making of holes by driving a punch through the metal and enlarging the same laterally—*drifting*. The operations are, therefore, distinct, though often employed on one piece. Thus a large hole cannot be formed by punching alone apart from power aids. The practice at the forge, therefore, is to punch a small hole, say, of $\frac{3}{4}$ in. or 1 in. diameter, and enlarge it by driving tapered drifts through it.

Obviously, a process of drifting has to be employed carefully, bearing in mind the remarks already made respecting the opening out of the fibres by upsetting, and the short fibre in some shapes. Thus the eye in a previous illustration [**156**] would not be a suitable article for formation by punching and drifting; but it would be much worse if made in iron than in steel, because steel has no difference in fibre. Another reason is that steel has from three to four times the ductility of iron, and will therefore endure as much more stretching. These are points that have a very important bearing on the selection of iron and steel for a given job. The use of mild steel, highly ductile, has changed much of the work of the smith, lessening welding and multiplying the forms that can be produced by the aids of punching and drifting. Fig. **156** would very well be made in steel if the hole were punched out at once, nearly or quite, to full size. But it would be bad in iron because of the short fibre at A, and worse still if drifted. The same remarks apply in a slightly less degree to **155**. But **154** would be an excellent case for punching and drifting.

Proper Employment of Punching. The proper place of punching and drifting operations, therefore, is in the smaller eyes and bossed ends, and if in steel, the larger ones also. The effects of excessive extension of fibre in steel can



206. SMITHY (Mather & Platt, Ltd., Salford)

be largely counteracted by compression in the contrary direction, work which is best done in dies coercing the outside.

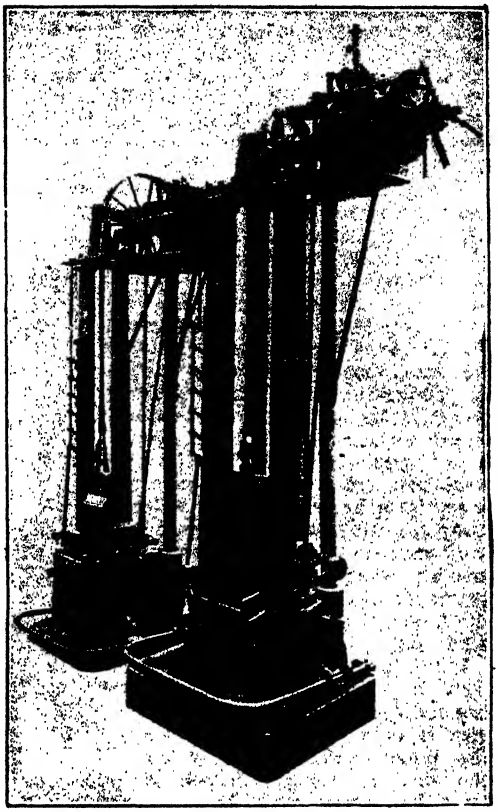
The methods of punching and drifting at the anvil are as follow.

The piece of work to be punched, being brought to a white or full red heat, is laid upon a *bolster*—a ring with a hole in it for the punching or burr to fall into. The punch, generally handled by withy rods, or iron rods, is driven by a sledge. If the work be shallow the punch will go right through; if not, the work must be turned over and the punch driven from both sides, meeting in the middle. If the mass of the boss be small, it will be enlarged by the act of punching, and will have to be corrected subsequently. If large, the metal will not yield sensibly in the lateral direction.

Drifting. *Drifting* means the insertion of tapered drifts made in sizes required. These are driven through with a hammer, successive ones being inserted until the required dimensions are obtained. Reheating may have to be done, because drifting stresses the material severely, and must, therefore, not be done except at a good red heat. Generally the outside is corrected with hollow swages while the drift remains in its hole, and this consolidates as well as imparts a neat finish to the bossed portion.

Die Forging or Stamping. Hitherto we have considered the work done at the anvil by methods that vary little in the hands of the country smith or the engine smith in the factory. But this is becoming a rapidly lessening volume, invaded by the work of the dies and power hammers. The subject is a wide one, and the practice is greatly subdivided now, being alike adaptable to the preparation of a few similar forgings or of thousands. Work may also be done partly at the anvil and partly in dies, or wholly in dies. A big piece may require two or more heats for its completion, or three or four small pieces may be forged at one heat. A good many different types of hammers and of forging presses are used in this work, actuated by steam, belt, board, compressed air, and water. Some shops will have but one hammer or press, others will number a hundred or more. The work has become of a cut and dried character, and grows more highly specialised constantly.

Removal of Fin. The principles of die forging are simple enough; the details tend to increase in complication. One difficulty lies in the formation of *fin*. That is, if a lump of metal be squeezed between dies, the surplus material becomes squeezed out between the joints of the dies, and forms fin. This has to be got rid of. There are two ways of doing so, depending on the shape of the forging. One is by obliteration, the other by cutting off in stripping dies. The first is suitable only for pieces that can be turned about in the dies, and these are only those of circular and square sections. Thus, in **190**, a bar is in course of reduction between dies, but the dies cannot close and finish the bar to the circular form because of the extension of the fin into the joints. But if the bar be turned



207 BRETT DROP HAMMER WITH PATENT LIFTERS
(Brett's Patent Lifter Co., Ltd., Coventry)

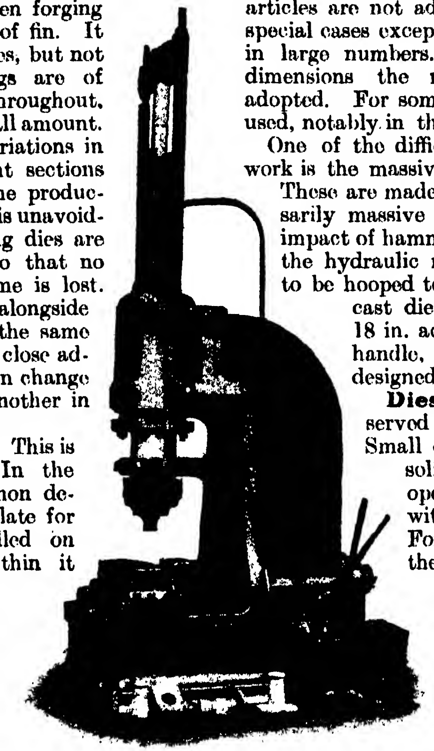
round as in **191**, the fin will be obliterated by being squeezed into the body of metal. More fin, but a less amount will form, of course, in the joints, but by turning the bar round constantly during the time it is being reduced the fin will be obliterated as rapidly as it is formed, and a truly circular shape will result. This fact also explains why in simple circular dies square edges are not necessary or even desirable, but a slight convexity is usually imparted as being favourable to the expulsion of fin, and to the turning round of the bar [**192**]. There is enough of the circle left to ensure the production of a circular shape on the bar which is being rotated in the dies. Bolts are forged in quantity in dies of this shape in the Ryder forging machine.

Other Methods. But take any object that cannot be rotated, and the inevitable formation of fin renders some other device for getting rid of it necessary. It may be removed either by a hand hammer, a few blows from which will detach it all round the hot forging, or, in a better system, by using stripping dies; thus, **193** shows a double-ended lever with the fin as formed around it during the act of forging. The stripping die [**194**] has the same outlines as the recess in the forging die, and its lever. But it is pierced right through to those outlines, so that when the forging is hammered down into it, the forging drops

through, leaving the fin, A, upon the face. In some forgings this stripping has to be repeated more than once. In another form of die the fin is squeezed out sideways, and left on the forging, to be cut off at any subsequent time. The die faces are then either recessed [**195**], or sloped [**196**], to receive the fin, the latter method being preferable.

The question might be asked whether it is not possible to estimate the amount of metal required to produce a given forging without having an excess of fin. It is in forgings of some shapes, but not in others. When forgings are of tolerably uniform section throughout, fin may be reduced to a small amount. But when there are big variations in the dimensions of adjacent sections the formation of fin in the production of the smaller sections is unavoidable. And when stripping dies are used they are arranged so that no appreciable amount of time is lost. They are either mounted alongside the formative dies under the same hammer, or on a hammer close adjacent, so that the man can change the forging from one to another in a moment.

Punching in Dies. This is done in several ways. In the engineers' smithy a common device is to use a guide plate for the punch, either dowelled on the die, or dropped within it over the forging as in A [**197**]. The punch is then bound to produce a central hole. The next [**198**] shows a drift being driven through a hole without effecting much enlargement. A is the bolster. Fig. **199** shows punches, *a a*, embodied in the dies themselves, which is generally done when the work is produced in large quantities. Fig. **200** shows a pair of dies that fit with dovetails into both anvil and tup.



208. HYDRAULIC FORGING PRESS MAKING STEEL BUFFERS AT SWINDON LOCO. WORKS
(Fielding & Platt, Ltd., Gloucester)

Figs. **201** to **204** are some examples of engineers' dies. The point to note in these is that the complete forging is not included in the dies, but only bossed ends. A good deal of such work is done in engineers' smithies.

Stamping. In the regular stamping shops the anvil occupies no place in the scheme of operations, but the hammers and dies are ubiquitous. Fig. **205** illustrates an arrangement where small work is being done in quantity, the "Brett" system. This serves two drop hammers, to right and left, under which two sets of work are being finished. There is also a trimming press for removing fin locally. The arrangement shown enables two forgers to rough out at the central hammer, leaving only the slight amount of finish to be done in the dies at the other hammers. In **205**, A is a nicking or fullering die, B shows the broad forming dies, and C the cutting-off dies. This enables a number of forgings to be made from a long bar.

There is, however, an important difference besides that of the numbers required off given forgings. The articles made in stamping shops are mostly of small dimensions and, therefore, they are eminently suitable for wholesale treatment. But engineers' forgings comprise many examples of massive work. Now, such articles are not adaptable to die forging, some special cases excepted, and they are not wanted in large numbers. For forgings of medium dimensions the method just mentioned is adopted. For some also the hydraulic press is used, notably in the railway and waggon shops.

One of the difficulties in dealing with heavy work is the massive character of the dies used. These are made in cast iron or steel, necessarily massive and strong to withstand the impact of hammer blows, or the pressure of the hydraulic machines. Often they have to be hooped to prevent fracture. When a cast die gets much beyond 15 in. or 18 in. across, it becomes awkward to handle, and liable to break unless designed in a very careful fashion.

Dies. Cast dies are mostly reserved for relatively massive work. Small ones are generally cut out of solid steel. This is often a tedious operation, done in machines, or with chisel, hammer, and file. For forgings of intricate shapes they are costly, but if the expense be spread over a large number of forgings, a die costing several pounds may cost only a fraction of a penny per forging made.

The dies of the engine smithy are frequently independent of the hammer on which they are used. The bottom die is simply laid on the anvil, and the top die laid over it, with the forging between, and is struck by the descent of the tup. But in the stamping shops the bottom die is attached to the anvil with set screws or with a dovetail, and the top one attached to the tup with a dovetail. The smith then only has to manipulate the forging with his hands. Generally, except in heavy machines, he regulates the vertical movements of the tup with one of his feet, operating a lever, so leaving his hands unfettered for the forging.

A typical smithy is shown in **203**. On the left are the forges, served by swinging jib cranes, on the right the anvils and steam hammers.

Fig. **207** shows a pair of drop hammers for die forging, worked by lifters in a cylinder operated by steam or compressed air, moving a wing piston. The tup is hoisted to the desired height and then allowed to drop. Fig. **208** is a hydraulic press, being more powerful than the drop hammers.

Continued

THE HUMAN WILL

The Will-not-to Stronger than the Will-to. Fallacies about Will-power. Weakness of Will and its Results. "Free-will" and "Fatalism"

Continued from page 2806

By Dr. C. W. SALEEBY

WE say that the character of a man expresses itself in his actions by means of his will. But this common mode of expression is scarcely adequate. It suggests that there is no will but such as leads to action; in other words, it ignores all those aspects of character which restrain action. It totally ignores the *will-not-to.* We must, therefore, modify the doctrine of the first sentence of this paragraph by omitting the three words, "in his actions," and making it run thus: *The character of a man expresses itself by means of his will, which has two aspects, negative and positive.*

The Will-not-to. Now, the theory which the present writer would submit to the reader is that the oldest and most fundamental part of the will is that *will-not-to* which we are so apt to forget. The reader will recall a pair of diagrams expressive of two stages of reflex action [page 2117]. Do they not appear to suggest that the essence of will is not positive, but negative, is inhibition rather than command? On this theory there is a certain reflex, or natural response, to all forms of stimulus. You feel hungry and eat, angry and strike. The "natural man" thus tends to be a reflex or impulsive man. Will, in the proper sense, plays no more part in him than in the lower animals; but the educated man, who, in the admirable phrase, is *master of himself,* has reached a higher level. He is no longer a reflex machine. He still experiences the natural tendency to respond to stimulus. But he has developed powers of inhibition which enable him to control his natural reflexes. Though angry, he may refrain from striking—whether from fear or magnanimity does not matter for our present purpose. When hungry he may refrain from eating, nor does it matter whether his motive be fear of indigestion or the knowledge that he is depriving another. At any rate, in such a man there has been evolved a power of will which is not positive but negative, which is not really a power of commanding his body to do certain things, but a power of commanding it not to do certain things.

"Indomitable" Will. It is indeed that power of inhibition which began to appear in the history of life directly there was introduced into the nervous system that first complexity illustrated in the diagram to which we have referred. Let us quote again from Huxley's famous definition of the ideal of education: "That man, I think, has had a liberal education . . . who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will—the servant of a tender conscience."

Here we see that will and vigour of will are regarded as exhibiting themselves not in action, as that word is ordinarily understood, but in restraining from action, in self-control, or inhibition. This subtle conception of will may seem unacceptable to some readers. When they speak of a man of indomitable will they do not mean the man who is master of himself, the man of whom Huxley speaks; they mean a man of the type of Napoleon, who will set before himself some ambition, and wade through blood to gain it. But the psychologist, who has some knowledge of mind in its diseased form, has a very different estimate of such cases. It may be said that the majority of instances of so-called "indomitable will" are really cases of loss of will. A person is consumed by an intense desire, by a lust of some kind, whether for power or for money, or for fame or for slaughter, or what not. Given this desire, which he may himself despise and of which he may long to be rid, all his actions become reflex. He is automatically urged to every course which favours his end; no considerations can restrain him: often he attains his end at a wholly disproportionate cost. The foolish spectator declares this to be a case of amazing will-power.

Desire Beyond Control. But here the present writer may be permitted to set down an analogy which he has long been turning over in his mind. Take the case of a patient who suffers from morphinomania. He knows that morphia will give him, for a time at any rate, ease of body or mind, or both. The case is the same with the slave of alcohol, cocaine, and many other drugs. No considerations will restrain such a patient. You may choose many means in order to deter him. He may be locked up, or he may have rendered his skin so painful that the injection of the drug causes agony; he may be compelled to go long journeys in order to obtain what he desires. His indomitable will, as foolish people would call it, will not be gainsaid. Professor James quotes such sayings as this: "Were a keg of rum in one corner of a room, and were a cannon constantly discharging balls between me and it, I could not refrain from passing before that cannon in order to get that rum." "If a bottle of brandy stood on one hand, and the pit of hell yawned on the other, and I were convinced I should be pulled in as sure as I took one glass, I could not refrain." The professor also quotes the instance of a man who, "while under treatment for inebriety, during four weeks secretly drank the alcohol from six jars containing morbid specimens. On asking him why he had committed this loathsome act, he replied: 'Sir, it is as impossible

for me to control this diseased appetite as it is for me to control the pulsations of my heart.' "

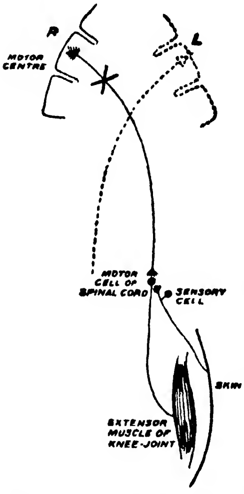
The "Explosive Will." Most amazing of all, perhaps, is the following, also quoted by Professor James, of an inebriate in an almshouse: "Within a few days he had devised various expedients to procure rum, but failed. At length, however, he hit upon one which was successful. He went into the woodyard of the establishment, placed one hand upon the block, and with an axe in the other struck it off at a single blow. With the stump raised and streaming he ran into the house and cried, "Get some rum! Get some rum! My hand is off!" In the confusion and bustle of the occasion a bowl of rum was brought, into which he plunged the bleeding member of his body, then raising the bowl to his mouth, drank freely, and exultingly exclaimed, 'Now I am satisfied.' "

Professor James quotes these cases as instances of what he calls the *explosive will*. The will, he says, may be explosive either from defective inhibition or from exaggerated impulsion. But it is quite plain that even in the cases we have quoted, which Professor James does not class as due to defective inhibition, it would be ridiculous to speak of such patients as having exceptional will-power. To credit with great will-power the man who struck off one hand in order to gain rum is to think superficially. The other patient had far better insight into his own processes when, having obtained alcohol even under the most loathsome conditions, instead of priding himself on his will-power, he said, "It is impossible for me to control this diseased appetite."

Will and Motive. The question, therefore, arises how far the cases of what is commonly regarded as great will-power must not be regarded as the necessary consequences of an intense appetite of some kind or another. Sometimes the appetite or motive may be noble, so that a philanthropist will go through obloquy and discouragement in order to gain his end. But this is not a case of will-power. Anyone else would do as he does if he felt as keenly about the misery or injustice in question. The driving power is not a strong will but the powerful motive. Or the appetite may be vicious, such as Napoleon's appetite for power. Here, again, there is no question of a strong will, but of an indomitable appetite. Given such an appetite, true strength of will would show itself in conquering it.

But the reader will reply that even in effecting such a conquest there must be a motive, and this is indeed true. Inhibition must have its motives just as much as permission or the refusal to inhibit. It follows, therefore, that the only wise sense in which we can speak of a strong will or a weak will is to employ these terms solely to indicate the degree of control which a higher nervous level has over a lower, or the degree to which one may postpone present ease or gratification for future happiness, or the degree in which lower motives are controlled by higher motives; in other words, will is inhibition, and the only real will is *the will-not-to*. The previous words of the writer may perhaps be quoted: "In other words, I believe that the human will, volition as we are conscious of it, is essentially not a positive but a negative thing, in the sense that a command is positive but permission negative." Action, on this view, is the result of permission given for a certain complex of what are really reflexes; in other words, action is the result of a cessation or inaction of inhibition on the part of the highest centres. They cease to restrain, and the result is action. On the other hand *inaction* (I do not mean inertia, but the power to sit still, to hold tight when the horse runs away, to "bide your time," to be a still man in a blatant land) is the really active and truly volitional process, since it depends on the active and positive power of inhibition or control exerted by the higher centres upon the lower.

Will and Disease. The theory that volition or will is ultimately inhibition, is supported by the facts of the physiology of the nervous system and especially by the remarkable facts of many diseases which interfere with the course of the nerve fibres of will from the brain. We have prepared a diagram in order to illustrate



these facts. It represents, very much out of scale, one of the pyramidal cells in the right motor area of the brain. From it there passes a long nerve fibre which, with thousands like it, constitutes one of the main paths of volition. After crossing over the middle line, this fibre ends in close relation to a motor cell in the spinal cord, and from this there passes a fibre that goes to the muscle which straightens the knee-joint. Now if you cross one leg over the other and tap the knee, the leg is jerked sharply forwards. This is known as the knee-jerk, and depends upon the activity of the motor cells in the spinal cord, one of which we have drawn. But if some injury occurs to the nerve fibre of what is technically called the *upper neuron*, such, for instance, as a hæmorrhage, at the point we have marked X, the knee-jerk is found to be enormously exaggerated; while at the beginning of such an accident, when the activity of the upper neuron is increased by irritation, the knee-jerk may be abolished altogether. These facts show that the upper neuron constantly exercises an inhibitory action upon the knee. When this action is removed, the lower neuron responds excessively to any stimulus. When it is increased the lower neuron is prevented from responding at all. These explanations are universally accepted. But what do they mean? Surely, that the paths of volition are primarily paths of inhibition, as indeed our

knowledge of the development of the nervous system certainly teaches. In other words, we are compelled to believe that the same nerve-cells and fibres can both restrain the knee-jerk and, at will, straighten the knee—can prevent the extensor muscle of the knee from acting or can permit it to act. The probab'lity would appear to be that the real action is the restraining action, and that "at any rate at first, when the brain centre came to *command* the spinal centre to act, all it really did was to refrain from the customary restraint—it did not *command* so much as *permit.*"

The Doctrine of "Free-will." Most readers are familiar, no doubt, with the old quarrel regarding "free-will and necessity." Most controversies are engendered by misunderstanding, and especially by the attachment of different meanings to terms which are supposed to have but one meaning. This controversy is a conspicuous instance. The upholders of free-will are supposed by their opponents to assert that the will is independent of all causes, whether causes present in the individual's inheritance or causes in the environment. The assertion of freedom of the will is supposed to mean that the will is arbitrary and uncaused. Put in this way the doctrine of free-will is an obvious absurdity.

The upholders of the doctrine of necessity, on the other hand, are supposed by their opponents to assert that human volitions and actions are necessary and inevitable. This doctrine is equally absurd as commonly understood, for it amounts to declaring that there is no such thing as will, or, as the present writer would prefer to say, no such thing as inhibition or self-control. This doctrine is obviously "inconsistent with everyone's instinctive consciousness, as well as humiliating to the pride, and even degrading to the moral nature of man."

Let us see now whether it is not possible for psychology to give an answer to this question in a manner which can scarcely be misinterpreted and which will be acknowledged by both parties.

Action is Never Uncontrollable. Perhaps the wisest discussion of this subject is to be found in the brief chapter "Of liberty and necessity" in the last book of Mill's great "System of Logic." Though Mill employs the word "necessity," he strongly feels how unsuitable it is. He says that certain errors, for instance, "would be prevented by forbearing to employ, for the expression of the simple fact of causation, so extremely inappropriate a term as necessity. That word in its other acceptations involves much more than mere uniformity of sequence; it implies irresistibleness. . . . The causes, therefore, on which action depends are never uncontrollable, and any given effect is only necessary provided that the causes tending to produce it are not controlled. . . . But to call this by the name necessity is to use the term in a sense so different from its primitive and familiar meaning, from that which it bears in the commonest occasions of life, as to amount almost to a play upon words."

"Fatalism." The consequence of this play upon words is that psychologists, and men of science generally, are declared on this question to be fatalists. But "a fatalist believes, or half believes (for nobody is a consistent fatalist) not only that whatever is about to happen will be the infallible result of the causes which produce it (which is a true necessarian doctrine), but, moreover, that there is no use in struggling against it; that it will happen however we may strive to prevent it." But this no sane psychologist believes, and since the term "necessity" is extremely liable to be confused with fatalism—the doctrine that will and character are impotent or mythical—it is much better for us to avoid the term altogether.

The doctrine held by psychology is much better called *determinism;* and this word has now very nearly ousted its predecessors. By determinism is meant the doctrine that human actions are determined by causes. Strictly speaking, that is all. It is a mere application in the realm of will of the philosophic and scientific doctrine that causation is universal. In general, determinism goes on to say that all the causes which determine human action may be gathered under two heads—heredity and environment. To quote Mill once more, the doctrine is this: "That, given the motives which are present to an individual's mind, and given likewise the character and the disposition of the individual, the manner in which he will act may be unerringly inferred; that if we knew the person thoroughly, and knew all the inducements which are acting upon him, we could foretell his conduct with as much certainty as we can predict any physical event. This proposition I take to be a mere interpretation of universal experience, a statement in words of what everyone is internally convinced."

What is Environment? The causes due to heredity need no further comment, but the use of the word *environment* must be explained. We mean by it very much more than Lamarck meant when he first introduced the phrase *milieu environnant.* We mean the whole of education—physical, mental, and moral. Further, we recognise abundantly that past environment profoundly affects character, especially in respect of the formation of habits, so that we react to present environment very differently in consequence. It is not true to say of a man "his character is formed for him and not by him." Our own desire to mould our character in a particular way is itself one of the most influential factors in determining it.

Again, if the word *free* be sanely used in this controversy, the psychologist can readily admit that the will is free. But it is a curious fact that, just as the word *necessity* has been used, in this connection, in an entirely special and arbitrary sense, so the word *free*, here used, bears a special meaning which would be regarded as absurd in any other connection. Indeed, there are three distinct senses in which the word has been used.

Sometimes by free-will it is meant to assert that the will is independent of all causes—internal and external—and that, to choose a case, when a man is affected *solely* by two motives, one weak and the other strong, he can refuse the stronger.

Secondly, by the assertion of free-will it is sometimes meant to assert that man is rational, while the lower animals are instinctive; that, instead of acting reflexly and immediately, as if only the present were of consequence, man has freedom to control himself and follow remote instead of merely immediate ends. But, after all, this simply means that man has developed the power of inhibition.

Thirdly, a specially moral meaning is attached to the phrase, and it is asserted that man is able to suppress his lower nature by his higher nature. This, of course, no one questions. But surely the use of the term free-will in order to indicate these special cases of inhibition is most misleading.

We Are Not Fatalists. Philosophically, some of us may reject determinism, but this is only because we do not properly understand it. When it comes to matters of practice, we never for a moment swerve from a constant and abiding faith in this doctrine. We extol and practise moral education because we know that the will is determined for good by the formation of good habits, the avoidance of evil ones, the provision of a moral environment, the inculcation of self-respect—and so on. We are anything but fatalists. Fatalism, translated into biological language, would be an assertion that heredity settled everything—that human character was given once and for all at birth, and would show itself in certain ways, any modifications of the environment notwithstanding. But that, of course, is precisely what determinists do not believe. They realise that the will of others—parents, friends, teachers, and society in general—can be brought to bear upon the inborn tendencies of any individual so as to modify them profoundly. This they may do in many ways; as, for instance, by generating within him a desire for self-modification or a desire to earn their sympathy or respect or goodwill. In such ways his character is modified and determined to a quite incalculable degree. To deny determinism is to assert that education is impotent to modify human action.

A Feeling of Moral Freedom. It is to be hoped that we have done something to clear up the confusion that constantly surrounds this subject. Combatants of both parties, the reader will now understand, have seen certain aspects of the truth. If this were not so, the controversy could scarcely have lasted so long. The so-called necessarians have seen that human action is modified by character and circumstances, and have thought it idle for their opponents to assert—as has sometimes been asserted foolishly—that the will is above all these forces. The libertarians have seen the equally certain truth that occasions constantly arise when the *ego* or self is conscious of a power of choice and of being drawn this way and that. There is what St. Paul described as a war within one's members. We have a feeling of moral freedom, and it is idle for the necessarians to deny it. It is a first-hand fact of consciousness, and cannot be questioned. Scientific determinism recognises this truth; it admits the potency of this power of choice; it admits the existence of the feeling of freedom; but it reserves to itself the right to trace these to their antecedent causes in heredity and environment.

"Judge Not." In a brief course such as this it is possible only to attempt to interest and stimulate the reader. If we have succeeded, many questions will arise in his mind to which we cannot here attempt an answer. What, for instance, does determinism make of such terms as merit, credit, responsibility? What is its judgment upon praise and blame, reward and punishment? These are great questions, and worthy of grave consideration. We should show ourselves unconscious of their importance if we were to attempt to deal with them in a perfunctory fashion. Merely let it be noted that determinism can be shown to be not inconsistent with a recognition of the practical value—indeed, the deterministic value—of praise and blame, punishment and reward. As for pronouncing ultimate judgments upon merit and upon demerit, determinism bids us hold our peace. It leads to a large and charitable estimate of human life. It supports the command, "Judge not," and it strongly inclines us towards the truth of that profound and beautiful saying, "tout comprendre c'est tout pardonner"—to understand everything is to pardon everything.

Continued

FARM BUILDINGS & WORKERS

Model Cattle Houses, Stables, Barns, and Sheds. Manure Preservation. Valuable Farm Hands. Earnings and Allowances

continued from page 2909

By Professor JAMES LONG

FARM BUILDINGS

The English homestead is in the great majority of instances still of inadequate formation. In the past the custom was to build in the form of a quadrangle or square, the house facing the manure yard, around three sides of which the barn, stables, and cattle buildings were constructed. This method was not a contribution to a healthy surrounding, however it might have facilitated the farmer's practice of watching both his men and his stock. Whatever the result on this score, the house should be built quite apart from the livestock and the manure yard, and still further from the dairy—which should not even adjoin the house, inasmuch as danger may follow the presence of sickness—and the water supply, which should be beyond suspicion, and therefore far removed from soil contaminated by both manure and sewage.

The American Practice. The buildings of the farm may be constructed either in detail or en bloc [see page 25]. In America it is a common and growing practice to erect round buildings which provide for almost all the requirements of the farm, a silo being in the centre, while the livestock are stalled in one or two circular or semicircular sets of standings, leaving room for the storage of food, implements, machinery, and practically all that is necessary. In this, as in other countries too, farm buildings of rectangular form are in some cases employed. One such building we may instance. It is of brick and slate, with a platform for hay or straw at each end; behind the platforms are granaries and stores for food, while beneath these are a cart-shed, some loose-boxes, the engine-house, and the milk-cooling house. The spaces under the platform at one end of the building are occupied by the dairy cows, their standings being ranged crosswise, while the horses are stalled under the platform at the other end. On one side of the building are ranges of boxes, while sliding doors are fitted in the centre of each side, so that waggons, carts, or a threshing machine can pass through. Right and left of the passage through the centre are spaces for the storage of corn, hay, or straw, this part of the building being practically a covered barn. Such a building thus provides for all contingencies but the sheltering of the implements and machinery of the farm, yet even these may occupy it at all times when it is not filled with the crops which have been mentioned. For some reason not always easy to understand, landowners, agents, farmers, and architects prefer separate buildings for each purpose, with the result that the expense involved is considerable, and the advantages very often most questionable.

Selection of the Site. It is important to remember that stock buildings should face the south, the sun having a purifying influence as marked as ventilation. The buildings should be in a fairly high situation in order to ensure their dry condition, and for the purpose of providing natural drainage. Sometimes, too, where the water-supply is at the homestead, its conveyance by gravitation to other parts of the farm is facilitated. Again, as the carting of manure involves considerable labour, it is well that it should travel downhill. As far as possible, too, the homestead should be equal in distance from all parts of the farm, otherwise the furthest fields obtain the smallest quantity of manure and the least attention. It should be near good pasture land in order that cows, horses, and swine may be turned out with great frequency and therefore with great advantage. Those who have visited Holland may have remarked upon the simplicity of the homesteads, which are there so commonly constructed in the form of a single building, although the dwelling almost invariably forms part of it, and this is its chief defect. Again, it is important that the road or roads to the homestead should be broad and sound, the crown being higher than the sides and all well metalled and drained.

Cattle Buildings. Buildings intended for cattle should be substantially built of brick, and their roofs slated or tiled, tiles being preferable, as they are cooler in summer and more easily repaired. The floors may be made of fluted concrete to give the animals a firm footing, of grooved fire brick laid in cement, or, in the case of the stalls, of chalk well levelled and covered with beaten earth, which is easily repaired. The house, or byre, intended for cows, which are preferably stalled in pairs, should be carefully planned. For each pair of cows a width of from 7 ft. to 8 ft. should be allowed, depending upon their size, while the depth from the manger, if a manger is supplied, to the edge of the gutter should be from 5½ ft. to 7 ft. Some farmers prefer stalls of the greater length, in which case the manure falls upon the floor, while others prefer short stalls, with the result that the hind feet stand upon the edge of the gutter, and so the manure falls within it, keeping the stall from being soiled. The gutter should be from 6 in. to 8 in. deep, on the stall side and from 5 in. to 6 in. deep on the passage side. It should be from 12 in. to 15 in. wide with a fall to the end of the buildings, from which the liquid passes into the drain and tank outside, which should be constructed for its reception and salvage. In the older type of cow-houses there are wooden mangers with racks above for hay.

In a new building, however, it is preferable to abandon the rack and to construct the manger of semicircular glazed fireclay. In this way cleanliness is practically ensured, while water can be turned on for the cattle to drink if this be found desirable. In some parts of England, however, no mangers are employed. The hay is placed on the paved floor in front of the cows, while the mixed foods are placed in small, well-painted tubs either direct from a barrow or a tramcar which is wheeled along the passage in front of the animals, or, as in many cases, the tubs are carried to the feeding-house and there filled and returned. Where cows stand in a single row, the passage behind should be 6 ft. in width, for it is here that the removal of the manure and the cleaning of the gutters is conducted. The passage in front of the cows should be at least 4 ft. in width to enable the feeder to pass along with his food barrow, or, where the animals stand in two rows, head to head, it should be 9 ft., so that two men may simultaneously feed if necessary.

Where the cattle are fed for the butcher, separate stalls for single or pairs are unnecessary; nor is so much space requisite. The animals are arranged so that as far as possible they cannot harm or rob each other of food, and therefore the smaller and weaker cattle are never placed next to the larger and stronger. Feeding, however, is largely conducted in boxes, a convenient size being 10 ft. by 10 ft., but inasmuch as the manure is not removed practically day by day, and as litter is constantly added, the floor rises, so that a depth of 2 ft. at least should be allowed in addition.

Stables. Stables for farm horses must be roomy, well ventilated, well drained, and well paved. The floors may be of concrete or firebrick, but never paved with stones or soft bricks. A stall 6 ft. in width should be provided for large horses, the floor sloping gradually to the shallow open gutter behind. This gutter, which should also have a fall, should convey the liquid to a drain outside the building, which, in its turn, should carry it to the liquid manure tank. If of concrete, the stall floor should be grooved as in the case of grooved firebricks in order to give the horses a firm foothold. The stable should be 16 ft. to 18 ft. wide, providing plenty of passage room for large horses and spaces for harness to hang on wall pegs, as well as for the corn bins and other necessary materials. The manger, which is better made of iron than of wood, should be 9 in. deep by 18 in. wide. If wood is employed it should be the hardest of oak. To admit plenty of light there should be windows, at least 3½ ft. square, made to open with ease; but in any case ventilators of the louvre pattern should be provided and so arranged that the air should be both admitted and returned.

Before constructing a piggery, it is well to examine some of the best of those known to exist, as many quite simple yet practical ideas will be obtained. Where a number of pigs are kept, however, a brick and tile building may be provided with a passage from end to end and sties on either side, the size varying with the size of the breed of pig kept. An inner door from the passage should be provided for each sty, together with a trough of fireclay or metal—this adjoining the passage so that it can be filled by the attendant under cover, the food being brought from the food house at one end of the building. An opening with a sliding door under control from the passage should be provided between the sty and the courtyard outside. Both floors may be of concrete, or grooved firebrick, with a slight slope towards a central gutter, which in each case should lead to the liquid manure tank already mentioned. [See pages 2370–1.]

It is important in constructing a piggery to prevent the possibility of it being undermined by rats. The food house should be supplied with a copper, or some equally convenient apparatus for cooking food, and with a tank for house-wash or food which it is intended to soak, where the practice of allowing meal to ferment in water is adopted. Metal bins are also essential for the protection and preservation of the food.

The Modern Barn. Whether a barn is essential to a farm is a matter which it is for the owner to decide. Under the conditions of to-day, we think no such structure is necessary except for the storage of chaff, which is much improved by packing in large quantities, or the occasional storage of unthreshed corn or of straw. A barn, however, is an expensive building, and may usually be abandoned in favour of an open straw barn, where both hay and corn can be stacked at will and protected against rain during hay time and harvest. Such a building may be constructed of iron—and there are many patterns on the market with arched corrugated roofs—or timber, the roofs in the latter case being of the ridge pattern and the boards fixed with half-inch interstices, through which the rain does not pass if grooves are made near the edges of each. The spaces admit of ventilation without admitting rain, and if the whole structure is well tarred or painted it will last many years, and prove of great value to the farmer.

Storing of Machines. Implement sheds are always necessary. They should be roomy, substantial, and conveniently placed for the storing of drills, rollers, harrows, ploughs, cultivators, horse hoes, hay rakes, and mowing machines and self-binders in particular. It is important that an implement shed should be large enough to permit of such work as cleaning and repairing machinery being carried out beneath them—as, for example, in wet weather, when many other items of labour can be performed under shelter. The roof may be slated or tiled, or even corrugated and painted. A corrugated iron roof of good quality weighs about 5 cwt. to the 100 sq. ft., while slates weigh from 7 cwt. to 9 cwt., and tiles from 8 cwt. to 15 cwt., depending upon the varieties selected. A wooden roof in which the timber is ¾ in. in thickness weighs about 2½ cwt. per sq. ft. A shed, or portion of a shed, should be reserved for carts,

waggons and the elevator, where this implement is used.

Granaries. A good granary is all important, and should be constructed of brick on a good foundation, with a smooth concrete floor, if this can be made perfectly dry, otherwise wood may be essential, with ventilation beneath. In this case, it is important to cover all the angles with metal, to prevent the entrance of rats and mice, as large quantities of grain are from time to time left on the granary floor on which it is dressed or winnowed before delivery. As stock foods, such as cakes and meals, are stored in the same building, the importance of dryness and ventilation will be recognised. There should be glazed windows, covered with fine, strong, perforated metal, facing the south, for the entrance of light and air when necessary. A granary is often one of the great sources of loss on a farm, where, owing to damp and vermin, corn is often damaged or destroyed altogether.

Manures. The salvage of manure, both solid and liquid, being of such importance in the maintenance of the vitality of the land, a tank of a size in accordance with the extent of the farm and the number of stock kept should be constructed in a spot most convenient for the reception of the drainage of the stables, piggeries, and cattle buildings. A tall pump and iron grating should be fitted above this tank, and in the centre of a floor of concrete or grooved firebrick, sloping from the outsides. Through the iron grating the liquid will drain into the tank. The solid manure should be packed above it and around the base of the pump. The manure stack should be built in such a position that the solid excrement from the buildings can be easily placed upon it from day to day, assuming that it is not directly carried to the land, which, all things considered, is perhaps the most convenient system. Most farmers, however, prefer to heap manure in the yard at some season or other, hence a roof should be erected above the stack to prevent saturation by rain. If packed tidily and kept cool by the occasional pumping of the liquid upon it, the loss will be reduced to a minimum. The liquid, however, should never be allowed to remain many days in the tank, unless it is diluted with water, in order to prevent the escape of ammonia. A liquid manure cart is, however, necessary, so that it can be carried away as often as possible, and certainly as often as necessary. By the adoption of this plan, there will be no scattering of manure over the whole yard, and no heaps in front of the doors of the cattle buildings, which disgrace the farmyard in almost every country.

The Engine. If a portable engine be employed upon the farm, a shed will be necessary for its protection; but if the engine be fixed, the engine house should be conveniently placed in order that coals may be kept close at hand, and that the various operations of pulping roots, cutting hay and straw into chaff, crushing cake, grinding corn into meal, and driving the cream separator—if such a machine be used—may be economically carried out. This will involve considerable thought in the arrangement of the shafting and the placing of the belts. It is evident, too, that the foods to be handled must be stored for the purpose as conveniently close to the engine house as possible, while the apartment in which the milk is separated should not be very far distant. It will be for the farmer to decide whether he employs a steam engine or an oil engine, or whether on extensive holdings it will be worth while to lay down a plant which, in addition to the provision of power for the work already named, will also provide electric light. We believe, however, that the time is near when a portable engine will be available not only for these purposes, but also for the purpose of draught in the field and on the road, as well as for threshing corn and performing almost every act of labour for which machinery is already responsible.

Reference to the dairy will be made in full in the section on DAIRY FARMING. It will now be sufficient to state that, with the exception of piggeries and feeding-boxes, buildings in which stock are kept should be at least 10 ft. in height, that there should be 800 cub. ft. allowed for each cow, 600 for store and fatting beasts, and 1,200 for horses, if ventilation is to be perfect and the health of the stock maintained. Further, that special care should be observed in selecting dry spots for each building, and in securing as much light as possible direct from the sun.

FARM SERVANTS

Duties of the Boy. It is true that the great majority of our farm labourers are the sons of farm labourers, and that they follow their occupation owing to the fact that their earnings are needed by their parents while they are yet children, and further, that employment upon the farm in which their father is engaged, or by an adjacent employer, to whom he is known, is easily obtained. Boys are able to assist the farmer in so many ways, especially during hay time and harvest, when, owing to the holidays, they are permitted to work, that an engagement may not only be obtained, but be retained for life if the servant is willing to satisfy the master. The training of a lad to become a farm labourer is a matter of experience; he gets most of his orders from the men, and tumbles into his work rather through a process of imitation than of education.

The boy is generally employed as an assistant to those who are respectively termed waggoners, carters, ploughmen, and horsekeepers or horsemen, in accordance with the custom of the country. The duties of these men are the charge of horses, and the performance of such forms of labour as require the assistance of the horse. These include ploughing and harrowing, cultivating, rolling, drilling, manure carting, mowing and reaping, and in almost all these cases the boy takes his part, assisting in cleaning out the stable, in cutting the chaff, in feeding, in carrying hay and straw, leading the horses when ploughing, where this is essential, riding the fore horse which assists in drawing the binder, leading the horses of the manure cart, driving the horses when harrowing, or raking the hay and the corn.

Promotion. All these and many more duties fall to the farmer's boy, who, with time, becomes more or less accomplished, and is then promoted to the rank of assistant or under carter, or second ploughman. It is true he receives all his orders and many hints from the older men, and he quickly learns not only how to harness and groom, but how to feed a horse properly. It falls to the lot of the farmer's boy, too, to clean the harness when he has learned the way. When he is old enough to take an interest in maintaining good condition in the horses under his charge, he quickly learns to value the quantity of corn and hay they receive, and to take care not only that they obtain the fullest rations which they are allowed, but to embrace every opportunity of obtaining extra food, and especially an occasional mash, a pint of linseed, or a few beans, that he may still further improve their condition and increase his own credit.

Dairy Work. The farmer's boy is not, however, confined to the stable and the work performed by the horses; he is in great demand among cattle, sheep, and cows. Here he learns to milk, to assist in cleaning out the mangers, the stalls, and the gutters, and in grooming the cattle, a practice which, however, is by no means common. He fetches the cows in from the fields at milking time—morning and night—and takes them back, and if he is a careful lad, he is entrusted to take the milk twice daily to the railway station.

Although the farm boy is generally quick in acquiring a practical knowledge of the work he has to perform, he is not always to be implicitly trusted, and, indeed, he is seldom paid in proportion to his actual value. The difference in the rate of wages paid to a careless lad and one who really does good service to his employer is very slight. The less capable are retained on the farm owing to the dearth of boys, while the capable receive only just sufficient to ensure their retention. If the best workmen—the remark applies to the man as well as the boy—knew their value, they would frequently demand higher wages and assuredly obtain them.

As the useful boy grows into a man he rapidly displays his capacity. He qualifies himself for a first hand by learning to thatch, first assisting an experienced hand during the hay and harvest seasons; he helps in all draining operations, volunteers to trim and lay a hedge, which requires considerable skill, and competes in a ploughing match, perhaps gaining a prize. His horses are turned out better than those of his neighbours, the harness is cleaner, and the feeding more carefully conducted. If he be in charge of cattle, the cows are well groomed and well milked, the rations are carefully prepared and supplied, and, in consequence, the stock thrive. If fattening stock be under his hand, he does his best to induce them to lay on flesh with rapidity.

Openings for Shepherds. Again, the boy is occasionally handed to the shepherd as an assistant. He learns to recognise the leading ewes of the flock, and he becomes acquainted with their ages, and the importance of identifying their age by their teeth. He is on the look-out for sheep with bad feet, which he quickly understands must be dressed immediately they are detected, and, during the hot weather, for sheep which have been struck by the fly, and others in which the maggot has already appeared, that they may be cleaned and dressed. He thus becomes acquainted with the duties of the shepherding of sheep, and in due course he obtains a place upon another farm as assistant shepherd, and finally as a full blown shepherd.

From Stable to Stud. It may now be pointed out that highly capable stockmen are always in demand, and they should be far in advance of the average farm stock hand in their knowledge of livestock, their feeding and management. There are in this country large numbers of breeding studs of Shires and Clydesdales, of Suffolks and Hackneys, of Coach horses and Polos. These studs are seldom the property of farmers in the ordinary sense of the word. They belong to men who are often wealthy and who are willing to pay high wages to first-rate hands. The well-trained farm hand is precisely the individual who is most needed, apparently because it has been his lot to manage horses, and to work long hours at small pay. A knowledge of these facts should be an incentive to the farm labourer who is able to transfer his services from the stable of the farm to the stable of the breeding stud.

Again, there are large numbers of men who breed cattle of the different varieties—Shorthorns and Red Polls, Jerseys and Guernseys, Herefords and Devons among others, for exhibition purposes, and who require servants who have been well trained on the farm, and who can be trusted to manage their herds, especially where the stock are exhibited at the numerous shows of the country for the purpose of acquiring and maintaining that condition which is so essential for the purpose of obtaining prizes. The wages paid to the stockmen in charge of a breeding or exhibition herd are much superior to those paid on the farm, and, if the remark may be made, there is much more enjoyment in the work, which is varied, which enables a man to see something of the country in which he lives, and which frequently enables him to add a bit of ground to his cottage, and to enjoy the privileges which follow upon its cultivation.

Breeding Sheep and Pigs. Although the opportunities afforded by sheep and pigs are not so numerous nor so profitable, nevertheless there are many instances in which gentlemen, who do not make farming a business, breed both varieties of stock as a hobby, although they generally persuade themselves that they conduct their work on strictly business lines. Pure breeds of sheep are kept either for ram breeding purposes or for exhibition. In the same way one or more pure breeds of swine are kept for similar purposes, and placed in charge of men who have acquired considerable knowledge by their experience, so that they are enabled to maintain the stock under their charge in high condition, and to win prizes at the exhibitions to which they are sent. There is, however, in all these cases one qualification essential

THE WAGES OF FARM SERVANTS

Average total weekly earnings of ordinary agricultural labourers in the United Kingdom in 1902, including the estimated value of allowances in kind. Taken by permission from the map in the Second Report by Mr. Wilson Fox, published by the Board of Agriculture in 1905

on the part of the man. He must be a judge of the quality of the breed of stock placed within his charge, and thus assist his master, who is frequently no judge, in improving both quality and character that he may achieve greater success.

We may take it that, speaking generally, the young labourer marries, rents a cottage, or obtains one from his employer, and settles down to his new life certainly not without hope of advancement. In some cases such a man raises his position by faithful and intelligent service, sometimes being promoted to the position of foreman or bailiff, and occasionally, by the aid of great thrift and industry, emancipating himself, first partially, and afterwards wholly, from service and making a livelihood on a few acres of land in or near his native village.

Average Earnings. The system of engagement of farm labourers differs with the locality. In Scotland, and parts of Wales, and in the North of England and the North of Ireland engagements are commonly made by the half year, single men being boarded and lodged, while married men are provided

with cottages. In other parts of the country both married and single men are, as a rule, hired and paid by the week and left to provide for themselves, although in a large number of instances the married men are supplied with cottages which are let with the farm. The system of boarding and lodging labourers is being gradually abandoned, like the hiring of work-people at fairs, although these institutions continue to be kept up in the North. In the year 1902, the average rate of wages paid to farm workmen, excluding foremen and casual men, was 17s. 5d. in England, 17s. 7d. in Wales, 19s. 5d. in Scotland, and 10s. 9d. in Ireland, or an average of nearly 1s. per week more than in 1898. Leading men obtained slightly higher wages. The sums paid were highest in Durham in England, and Glamorgan in Wales, while the lowest were in Oxford, Suffolk, and Gloucester, ranging from 11s. (without extras) upwards.

In most English counties the weekly wage is supplemented by piecework, such as hedging and ditching, draining and thatching, sheep shearing, and manure spreading, lifting potatoes, mowing, hoeing, and root singling; the total sums earned under these heads range from £5 to £7 per annum. Shepherds, too, usually obtain extra payment for the lambs born or reared, and occasionally stockmen are paid for calves. Another addition to the annual income of the labourer is the harvest pay. In 1904, taking 97 farms from which returns were obtained as a basis, the harvest covered 24 working days, against 33 days in 1902, and 24 days in 1901. The highest earnings were £7 5s. 7d. per man in the eastern counties, including Huntingdonshire, Cambridge, and Lincoln. In the midland counties these payments averaged £5 13s. 6d., while in the south and south-west the payments on 392 farms averaged £4 17s. 2d. In East Anglia the men usually receive a fixed sum to cover the harvest. In other parts of the country a round sum is paid in addition to the weekly wages, or these wages are increased and beer supplied in stipulated quantities. In some cases, however, the men are paid a fixed sum per day, or a fixed sum plus overtime. It is, however, not an uncommon practice to let portions of the work, and these remarks apply, to a large extent, to haytime and piecework.

Allowances. Farm labourers in many cases receive allowances in addition to their wages. Apart from the cottage or cottage and garden with which so many are supplied, they are allowed potatoes, or potato plots, or a given area is planted with potatoes for each man on the farm itself. Again, beer is allowed during harvest, haytime, and threshing, sheep washing and sheep shearing. Beer, however, is replaced by cider in some districts, and by milk, tea, coffee, or cocoa in particular instances. A cow is sometimes allowed grazing, straw is supplied for pigs, or a given quantity of pork or bacon is provided.

In cases of sickness or absence, and sometimes during wet weather, wages are stopped by employers, although there are districts, especially in the North, where payments continue to be made during these circumstances. Most farmers, however, expect their men to be members of a club, from which they receive weekly sums during sickness and the attendance of a doctor; but, although custom largely prevails, much depends upon the individual employer.

In 1902, wages varied in Wales from 15s. 8d. in Cardigan and 16s. 7d. in Anglesea and Pembroke to 21s. 3d. in Glamorganshire. As in some parts of England, wages vary in accordance with the proximity of mines and quarries, the highest sums paid for this class of work largely influencing the wages paid to labourers. It is seldom that wages in cash reach £1 a week; indeed, with allowances added, this figure is not often exceeded. Allowances in kind, however, are not numerous on the Welsh farm.

In Scotland, where the average total earnings vary from 17s. 7d. in Caithness to 22s. in Renfrew, Stirling, Lanark, and Dumbarton, allowances in kind are much more numerous. In addition to cottages and gardens, the men receive potatoes or the use of potato land, fuel, oatmeal, milk, and manure.

Wages in Ireland. In Ireland wages are the lowest in the western counties, reaching from Mayo to Cork. Although hired labourers in this part of the country are very few in number, owing to the fact that the inhabitants occupy the land, which they till for themselves with the assistance of their sons, large numbers of men leave the western counties for England and Scotland, not only during the harvest season, but for months together, their absence frequently extending from haytime to the lifting of the potato and root crops. They live on very small sums, sending the bulk of their earnings home to their families. Piecework is but little practised in Ireland, where the allowances in kind are extremely few. The total weekly earnings of Irish labourers in their own country vary from 8s. 9d. in Mayo to 13s. in Down. Many of the men, however, have the advantage of cheap dwellings with plots of land attached, the average area being about half an acre—although, under the Labourers Acts, it may reach an acre in extent. Through the medium of these Acts nearly 20,000 substantial cottages have been erected, and are let at an average rent, land included, of about 10½d. per week.

Hours of Work. The farm labourer's working day is shorter than was formerly the case, the hours depending in a large measure upon supply and demand. In districts where the demand exceeds the supply the men have curtailed the hours. Thus 6 a.m. to 6 p.m., with time for breakfast, lunch, and dinner, has been reduced to 7 a.m. until 5.30 p.m., with time for lunch and dinner only. Horsemen, stockmen, and milkers are usually required to commence at 6 a.m.—in some cases still earlier, ploughmen turning out with their teams at 7 a.m. and returning at 2 p.m., in some cases having only stopped work for lunch, and at 4 p.m. in other cases, when they return for dinner and go back to the field. Scotch farmers in England, however, frequently keep their men in the field until 5 p.m.

Continued

DRAWING FOR ENGINEERS

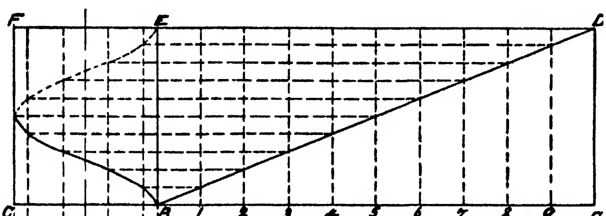
Bolts and Nuts. The Screw Thread. English and American Standards. Rivets and Riveting. Tables of Proportions for Screws, Nuts, Keys, etc.

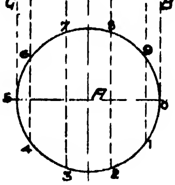
TECHNICAL DRAWING continued from page 2783

By JOSEPH W. HORNER

Fastenings. The various forms of fastenings used by engineers for connecting the component parts of machines and structures comprise screws, bolts and nuts, rivets, keys, cottars, pins, etc. The particular element to be used for a joint depends upon the formation of the parts and upon the materials of the same ; thus the permanent joints of girders and boilers are invariably riveted. Work which must be taken apart for periodical examination and adjustment is bolted together. Engine cylinder and valve covers, bearing caps, etc., come under this category ; wheels, cranks, couplings, etc., are keyed upon their shafts ; rods and sockets are cottared together.

Screw Threads. The essential element of the bolt and nut is the screw thread, the edge of which is a helix or spiral. Fig. **13** shows the development and projection of a helix upon a cylinder A, which is shown in plan with ten equidistant points marked thereon ; the rectangle B, C, D, E shows the development of the circumference of the cylinder, the diagonal B D representing the developed thread ; the vertical dotted lines 1 to 10 are the developed equidistant points ; the rectangle E, F, G, B is the projected elevation of the cylinder. Marking the points off for the projected path of the helix is now a simple matter of projection. The vertical distance from B to E is the " pitch " of the screw, being the distance advanced in one turn of the spiral. It is not really necessary to draw the development of the spiral in order to produce the elevation ; if the pitch B, E is divided into the same number of equal parts that the plan is divided into, and horizontal lines be drawn therefrom to meet the vertical projected lines, the resulting intersecting points give the path of the thread. Applying this principle to actual screws, **14** shows an ordinary triangular or V thread and **15** shows a square thread.



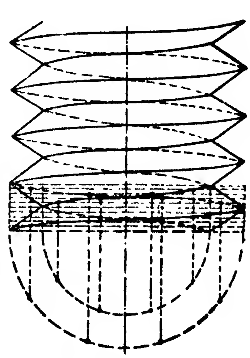


13 THE HELIX

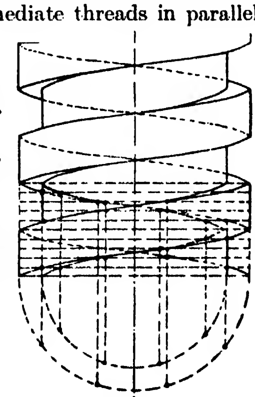
Sections of Screw Threads. The principal sections of screw threads are illustrated in **16** to **20**. The English standard V thread is the Whitworth [**16**]. The angle of the V is 55 degrees, and the top and bottom, instead of finishing in a sharp V, are each rounded off to the extent of one-sixth of the total depth. The American standard V thread is the Sellers [**17**]. The angle of the V is 60 degrees and finishes square at the top and bottom with one-eighth of the depth taken off. The square thread appears in **18** and **19**, the latter being a slightly modified form, the width of the thread at the point being less than at the base ; such a thread is used where the nut is split through and disengages by moving sideways, as in the leading screw of lathes, etc. In the buttress thread [**20**] one face of the screw is vertical whilst the other is usually 45 degrees ; the top and bottom is finished square as in the Sellers thread.

The V thread is used for ordinary bolts and nuts ; the square thread is used to transmit motion, or as a means of obtaining a leverage. With a V thread there is a bursting action on the nut which is absent in the square thread ; the latter, however, is not so strong, because its diameter under the thread is less than in the case of the V. The buttress thread is used where the load always comes in one direction only, such as on the breech screws of guns.

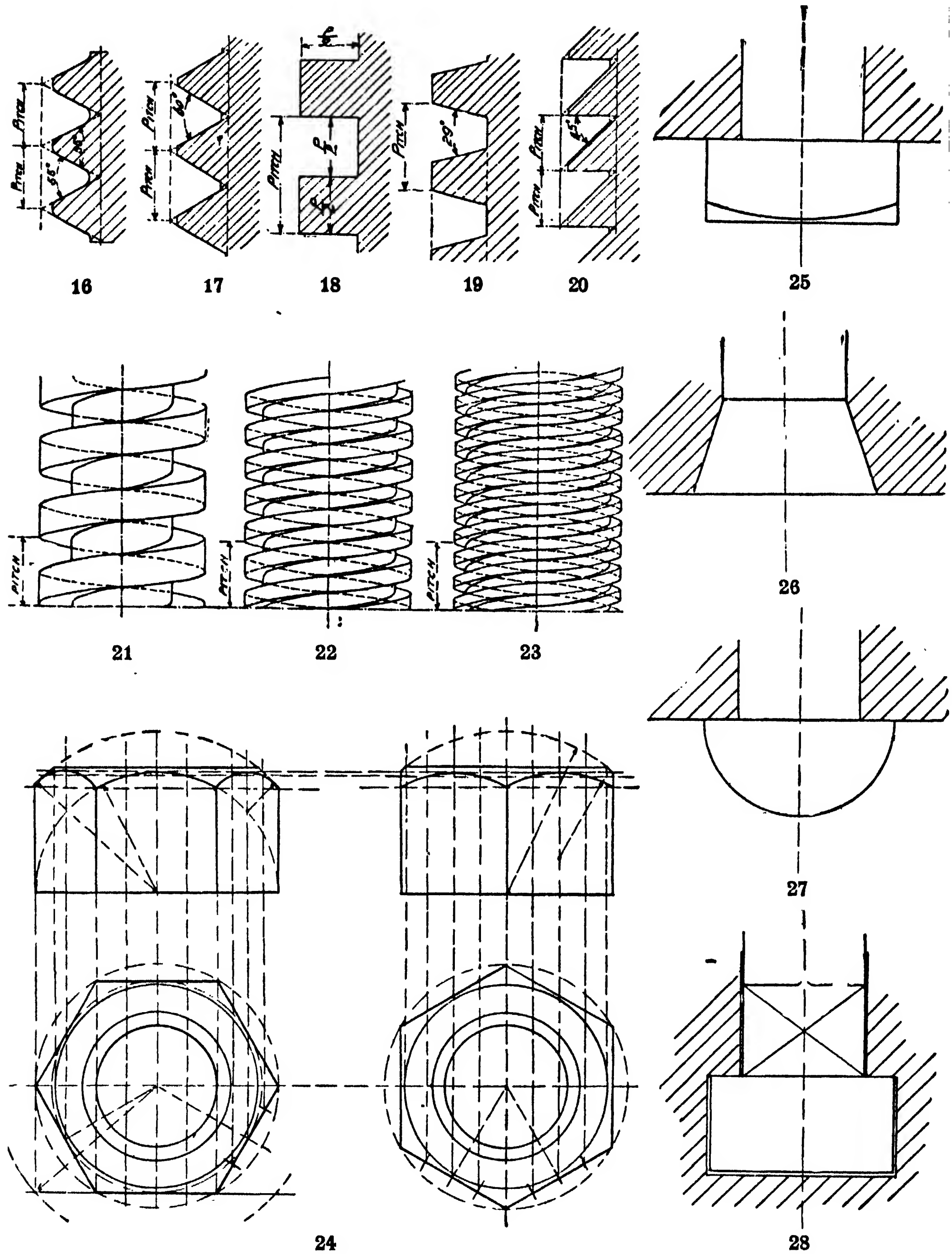
Multiple Screw Threads. A screw may be made with two or more threads without altering the pitch, the result being to reduce the section of the thread and to increase the diameter at the bottom of the thread. In the case of long-pitched screws this becomes a necessity. Fig. **21** shows a single-thread screw, **22** a double-thread, and **23** a triple-thread screw, all having the same pitch. It will be observed that the principle involved is the reduction of the section of the thread and the insertion of intermediate threads in parallel



14. V-SCREW



15. SQUARE SCREW



DETAILS OF SCREWS
16. Whitworth V thread **17.** Sellers V thread **18** and **19.** Square threads **20.** Buttress thread **21.** Single-thread screw **22.** Double-thread screw **23.** Triple-thread screw **24.** Whitworth nut **25.** Square head **26.** Countersunk head **27.** Snap head **28.** T-head

paths; the depth of a square thread being equal to its width it becomes reduced accordingly, and the diameter at the bottom becomes correspondingly greater. In this way a long-pitched screw may be made without unduly reducing its strength.

The two tables on next page give the regular dimensions of standard screw threads.

The third table of screws is used for gas and water pipes, where the fineness of pitch is necessary on account of the thin metal of which the pipes are composed.

WHITWORTH SCREW THREADS—ENGLISH STANDARD

Diameter of Bolt.	Threads per Inch.	Diameter at Bottom of Thread.	Area at Bottom of Thread.	Boltheads and Nuts. Width Across Flats.	Boltheads and Nuts. Width Across Corners.	Boltheads and Nuts. Depth of Bolt-head.
in.		in.	sq. in.	in. in.	in. in.	in. in.
3/16	24	0·134	0·014	7/16	1/2 and 1/64	1/8 and 1/32
1/4	20	0·186	0·027	1/2 and 1/64	9/16 ,, 3/64	3/16 ,, 1/32
5/16	18	0·241	0·046	9/16 ,, 3/64	11/16	1/4 ,, 1/64
3/8	16	0·295	0·068	11/16 ,, 1/64	13/16	5/16 ,, 1/64
7/16	14	0·346	0·094	13/16 ,, 1/64	15/16 ,, 1/64	3/8
1/2	12	0·393	0·121	7/8 ,, 1/32	1 1/16	7/16
9/16	12	0·455	0·155	1 ,, 1/64	1 1/8 ,, 1/32	7/16 ,, 3/64
5/8	11	0·508	0·204	1 ,, 3/32	1 1/4 ,, 1/64	1/2 ,, 3/64
11/16	11	0·571	0·256	1 3/16 ,, 1/64	1 3/8 ,, 1/64	9/16 ,, 1/32
3/4	10	0·622	0·304	1 1/4 ,, 3/64	1 1/2	5/8 ,, 1/32
13/16	10	0·684	0·367	1 3/8 ,, 1/64	1 9/16 ,, 1/32	11/16 ,, 1/64
7/8	9	0·733	0·422	1 7/16 ,, 3/64	1 11/16 ,, 1/64	3/4 ,, 1/64
15/16	9	0·795	0·496	1 9/16 ,, 1/64	1 13/16 ,, 1/64	13/16
1	8	0·840	0·554	1 5/8 ,, 3/64	1 15/16 ,, 1/64	7/8
1 1/8	7	0·942	0·697	1 13/16 ,, 3/64	2 1/8 ,, 1/32	15/16 ,, 3/64
1 1/4	7	1·067	0·894	2 ,, 3/64	2 5/16 ,, 3/34	1 1/16 ,, 1/32
1 3/8	6	1·162	1·058	2 3/16 ,, 1/32	2 1/2 ,, 3/64	1 3/16 ,, 1/64
1 1/2	6	1·287	1·299	2 3/8 ,, 1/32	2 3/4 ,, 1/32	1 5/16
1 5/8	5	1·369	1·472	2 9/16 ,, 1/64	2 15/16 ,, 1/32	1 3/8 ,, 3/64
1 3/4	5	1·494	1·753	2 3/4	3 3/16	1 1/2 ,, 1/32
1 7/8	4 1/2	1·590	1·986	3 1/16	3 7/16 ,, 3/64	1 5/8 ,, 1/64
2	4 1/2	1·720	2·311	3 1/8 ,, 1/32	3 5/8	1 3/4
2 1/4	4	1·930	2·926	3 1/2 ,, 3/64	4 1/16 ,, 1/32	1 15/16 ,, 1/32
2 1/2	4	2·180	3·733	3 7/8 ,, 1/64	4 7/16 ,, 3/64	2 3/16
2 3/4	3 1/2	2·384	4·464	4 3/16	4 13/16 ,, 1/64	2 3/8 ,, 1/32
3	3 1/2	2·634	5·450	4 1/2 ,, 1/32	5 3/16 ,, 3/64	2 5/8
3 1/4	3 1/4	2·856	6·402	4 13/16 ,, 3/64	5 9/16 ,, 1/32	2 13/16 ,, 1/64
3 1/2	3 1/4	3·105	7·563	5 1/8 ,, 3/64	5 15/16 ,, 3/64	3 1/16
3 3/4	3	3·320	8·673	5 1/2 ,, 3/64	6 3/8 ,, 1/32	3 1/4 ,, 1/32
4	3	3·573	10·027	5 15/16 ,, 1/64	6 7/8	3 1/2
4 1/4	2 7/8	3·804	11·365	6 3/8	7 5/16 ,, 3/64	3 11/16 ,, 1/64
4 1/2	2 7/8	4·054	12·908	6 13/16 ,, 1/64	7 7/8	3 15/16
4 3/4	2 3/4	4·284	14·404	7 1/4 ,, 3/64	8 7/16	4 1/8 ,, 1/32
5	2 3/4	4·534	16·146	7 3/4 ,, 3/64	9 ,, 1/64	4 3/8
5 1/2	2 5/8	5·012	19·720	8 13/16 ,, 1/32	10 3/16 ,, 1/32	4 13/16
6	2 1/2	5·487	23·640	10	11 1/2 ,, 3/64	5 1/4

SELLERS SCREW THREADS—AMERICAN STANDARD

Diameter of Bolt.	Number of Threads per Inch.	Diameter at Bottom of Thread.	Area at Bottom of Thread.	Diameter of Bolt.	Number of Threads per Inch.	Diameter at Bottom of Thread.	Area at Bottom of Thread.
in.		in.		in.		in.	
1/4	20	0·185	0·027	2	4 1/2	1·712	2·302
5/16	18	0·240	0·045	2 1/4	4 1/2	1·962	3·023
3/8	16	0·294	0·068	2 1/2	4	2·176	3·719
7/16	14	0·344	0·093	2 3/4	4	2·426	4·620
1/2	13	0·400	0·126	3	3 1/2	2·629	5·428
9/16	12	0·454	0·162	3 1/4	3 1/2	2·879	6·510
5/8	11	0·507	0·202	3 1/2	3 1/4	3·100	7·548
3/4	10	0·620	0·302	3 3/4	3	3·317	8·641
7/8	9	0·731	0·420	4	3	3·567	9·963
1	8	0·837	0·550	4 1/4	2 7/8	3·798	11·329
1 1/8	7	0·940	0·694	4 1/2	2 3/4	4·028	12·753
1 1/4	7	1·065	0·893	4 3/4	2 5/8	4·256	14·226
1 3/8	6	1·160	1·057	5	2 1/2	4·480	15·763
1 1/2	6	1·284	1·295	5 1/4	2 1/2	4·730	17·572
1 5/8	5 1/2	1·389	1·515	5 1/2	2 3/8	4·953	19·267
1 3/4	5	1·491	1·746	5 3/4	2 3/8	5·203	21·262
1 7/8	5	1·616	2·051	6	2 1/4	5·423	23·098

In these tables many dimensions are given in decimals of an inch in order to attain accuracy in calculation. For the purposes of drawing, it is convenient to convert these figures into vulgar fractions. The lower table on this page showing the decimal equivalents of an inch is given to facilitate the operation.

the latter case a square neck is made so as to prevent turning when the nut is screwed home; the head has the same maximum diameter and depth as the previous example. The T head [28] is applied to plummer blocks and machine tool tables and face plates; the length and depth of head are as in the snap and counter-

WHITWORTH GAS THREADS

Size.	Diameter at Top of Thread.	Diameter at Bottom of Thread.	Number of Threads per Inch.	Size.	Diameter at Top of Thread.	Diameter at Bottom of Thread.	Number of Threads per Inch.
in.				in.			
$\frac{1}{8}$	0·3825	0·3367	28	$1\frac{5}{8}$	2·021	1·905	11
$\frac{1}{4}$	0·518	0·4506	19	$1\frac{3}{4}$	2·16	2·042	11
$\frac{3}{8}$	0·6563	0·5889	19	$1\frac{7}{8}$	2·245	2·1285	11
$\frac{1}{2}$	0·8257	0·7342	14	2	2·347	2·2305	11
$\frac{5}{8}$	0·9022	0·8107	14	$2\frac{1}{4}$	2·5875	2·471	11
$\frac{3}{4}$	1·041	0·9495	14	$2\frac{1}{2}$	3·0013	2·8848	11
$\frac{7}{8}$	1·189	1·0975	14	$2\frac{3}{4}$	3·247	3·1305	11
1	1·309	1·1925	11	3	3·485	3·3685	11
$1\frac{1}{8}$	1·492	1·3755	11	$3\frac{1}{4}$	3·6985	3·582	11
$1\frac{1}{4}$	1·65	1·5335	11	$3\frac{1}{2}$	3·912	3·7955	11
$1\frac{3}{8}$	1·745	1·6285	11	$3\frac{3}{4}$	4·1255	4·009	11
$1\frac{1}{2}$	1·8825	1·765	11	4	4·339	4·223	11

Bolts and Nuts. The dimensions of standard Whitworth boltheads and nuts are given in the table of Whitworth screws, and **24** shows the correct proportions and development of a nut.

Boltheads vary considerably according to requirements. Figs. **25** to **29** show a number of forms in common use; the square head [25] has a width of $1\frac{1}{2}$ times the bolt diameter plus $\frac{1}{8}$ in., and a depth of two-thirds of the diameter;

sunk heads. The eye bolt [**29**] is applied to examination doors, etc., where it is convenient to simply slack the nut and swing the bolt to one side.

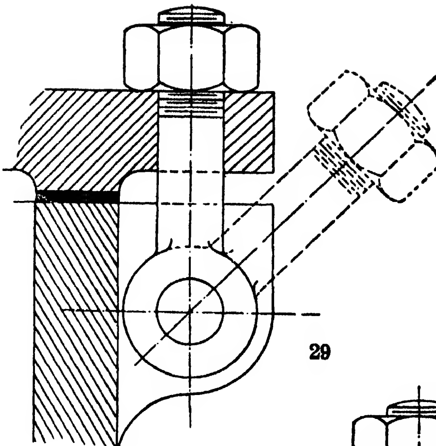
Foundation Bolts. Foundation bolts are used to secure machine tools, engines, cranes, columns, etc., to masses of masonry or concrete. A common form of light bolt is shown in **30**; the portion which enters the concrete is rectangular in section, with two faces jagged, the

DECIMAL EQUIVALENTS OF FRACTIONAL PARTS OF AN INCH

Fractions.	Decimals.	Fractions.	Decimals.	Fractions.	Decimals.	Fractions.	Decimals.
$\frac{1}{64}$	0·015625	$\frac{17}{64}$	0·265625	$\frac{33}{64}$	0·515625	$\frac{49}{64}$	0·765625
$\frac{1}{32}$	0·03125	$\frac{9}{32}$	0·28125	$\frac{17}{32}$	0·53125	$\frac{25}{32}$	0·78125
$\frac{3}{64}$	0·046875	$\frac{19}{64}$	0·296875	$\frac{35}{64}$	0·546875	$\frac{51}{64}$	0·796875
$\frac{1}{16}$	0·0625	$\frac{5}{16}$	0·3125	$\frac{9}{16}$	0·5625	$\frac{13}{16}$	0·8125
$\frac{5}{64}$	0·078125	$\frac{21}{64}$	0·328125	$\frac{37}{64}$	0·578125	$\frac{53}{64}$	0·828125
$\frac{3}{32}$	0·09375	$\frac{11}{32}$	0·34375	$\frac{19}{32}$	0·59375	$\frac{27}{32}$	0·84375
$\frac{7}{64}$	0·109375	$\frac{23}{64}$	0·359375	$\frac{39}{64}$	0·609375	$\frac{55}{64}$	0·859375
$\frac{1}{8}$	0·125	$\frac{3}{8}$	0·375	$\frac{5}{8}$	0·625	$\frac{7}{8}$	0·875
$\frac{9}{64}$	0·140625	$\frac{25}{64}$	0·390625	$\frac{41}{64}$	0·640625	$\frac{57}{64}$	0·890625
$\frac{5}{32}$	0·15625	$\frac{13}{32}$	0·40625	$\frac{21}{32}$	0·65625	$\frac{29}{32}$	0·90625
$\frac{11}{64}$	0·171875	$\frac{27}{64}$	0·421875	$\frac{43}{64}$	0·671875	$\frac{59}{64}$	0·921875
$\frac{3}{16}$	0·1875	$\frac{7}{16}$	0·4375	$\frac{11}{16}$	0·6875	$\frac{15}{16}$	0·9375
$\frac{13}{64}$	0·203125	$\frac{29}{64}$	0·453125	$\frac{45}{64}$	0·703125	$\frac{61}{64}$	0·953125
$\frac{7}{32}$	0·21875	$\frac{15}{32}$	0·46875	$\frac{23}{32}$	0·71875	$\frac{31}{32}$	0·96875
$\frac{15}{64}$	0·234375	$\frac{31}{64}$	0·484375	$\frac{47}{64}$	0·734375	$\frac{63}{64}$	0·984375
$\frac{1}{4}$	0·25	$\frac{1}{2}$	0·5	$\frac{3}{4}$	0·75	1	1·0

it is used for woodwork in combination with a washer plate, or alone for rough machinery. A countersunk head [26] is used where a flush surface is required; the large diameter is about $1\frac{1}{2}$ times the bolt diameter, and the depth of the cone is three-quarters of the diameter. The snap head [27] is used for footplates and planking. In

hole is taper, and is filled in with liquid concrete, or lead or sulphur, as the case may be. Another form of foundation bolt is illustrated in **31**, where it passes right through the concrete, and has a washer plate and cottar fitted below; snugs are cast upon the washer plate to prevent the bolt from turning when the nut is screwed



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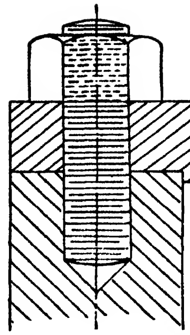

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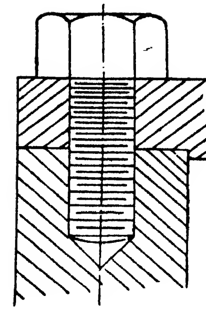

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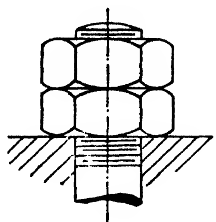

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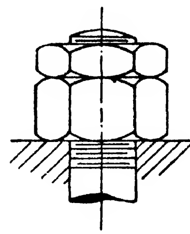

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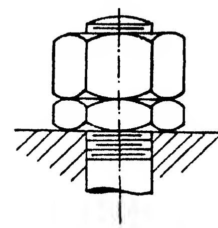

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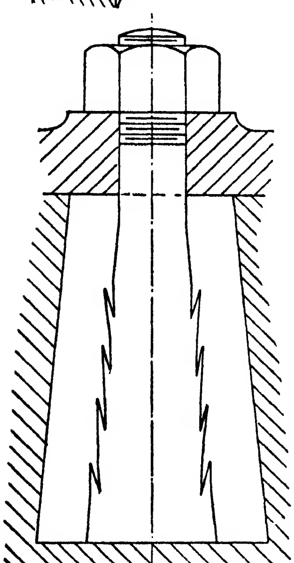

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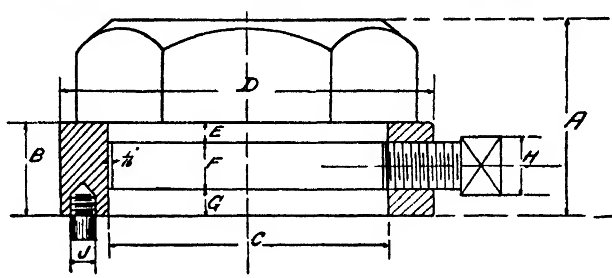

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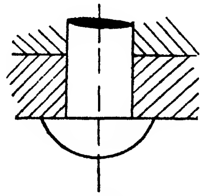

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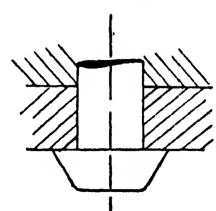

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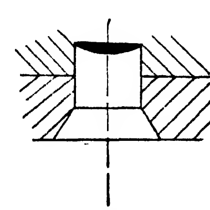

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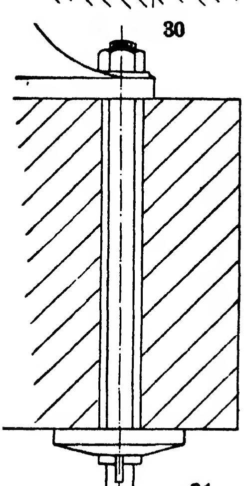

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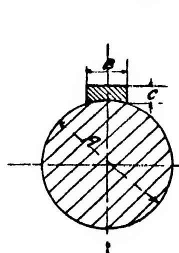

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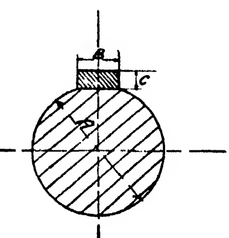

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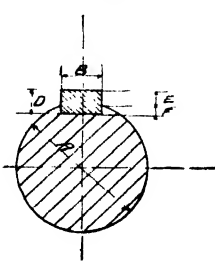


43

BOLTS, NUTS, RIVETS, AND KEYS

29. Eye bolt **30** and **31.** Foundation bolts **32.** Stud bolt **33.** Tap bolt **34, 35** and **36.** Lock nuts **37.** Collar nut **38.** Snap-head rivet **39.** Pan-head rivet **40.** Countersunk rivet **41.** Saddle key **42.** Flat key **43.** Sunk key

home. The sections and proportions of cottars are discussed in the next lesson.

A stud is a piece of rod screwed at each end, and is used where a through bolt cannot be arranged for. Fig. **32** shows a stud in place; the lower end is tapped into the body metal of a cylinder, whilst the upper end receives the nut. Fig. **33** shows a tap bolt; it is very similar to a stud, but has the head in one piece with the bolt. It is used under similar circumstances to the stud, but chiefly when there is no necessity for frequent removal.

Locking Nuts. There are various devices for preventing nuts working loose under shock and vibration. A common method is to put two nuts instead of one, the upper nut being screwed down hard enough to take the load, the nuts being tightly wedged together. There is no theoretical necessity for the lower nut to be as thick as the main or outer one, but in practice, an ordinary spanner being too thick to hold a thin nut, both of them are made three-fourths the full depth [**34**]. Where thin bottom nuts are provided, they frequently get put on the top, as in **35**, instead of at the bottom, as in **36**. Needless to say, this is not correct, as the full strength of the bolt is not then taken advantage of. Another method is to secure the nut by a set screw and collar, as in **37**, a table of sizes of which is given below.

Nuts are locked also by inserting a spring

DIMENSIONS OF COLLAR LOCK-NUTS

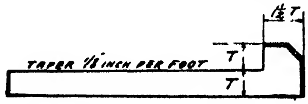
Bolt Dia.		B		D						
In.	In.		In.	In.	In.	In.				
1	1¾			2¼						
				2⅞						
				[illegible]						
1½	2	,,	2 5/16							
1⅝			2½							
			2⅞	3¾						
			3 1/16							
			[illegible]							
				4 1/16						
				4 3/16						
				5 1/16						
				5¼						
			4⅞							
				7⅛						
4½	4½	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	,,	1
	5½									
				10⅛						

washer underneath; there are various patented forms, all of which have the same object in view —namely, the exertion of a pressure against the nut, which is capable of following it up and keeping it tight under vibrations.

Rivets. Rivets and riveting will be dealt with in the course upon DRAWING FOR BOILER MAKERS; but the mechanical engineer is frequently called upon to deal with riveted work.

We show the usual types of rivets; the snap head [**38**], the diameter of which is 1·7 times the diameter of the body, whilst the depth is ·6 times; the pan head [**39**], of the same general proportions, but pan-shaped in form; and the countersunk [**40**], the maximum diameter of which is 1·6 times that of the body, the depth is made to suit the thickness of the plate, and is generally ·4 times the diameter of the body.

The diameter of a rivet varies with the thickness of the plates to be secured together. For plates and sections varying from ⅜ in. to ¾ in. thick, the common practice is to use ¾ in. diameter rivets, and space them 4 in. apart centre to centre. This spacing is termed the "pitch" of the rivets. Above ¾ in. plates the rivets may be ⅞ in. diameter for plates up to 1 in. thick, and 1 in. diameter up to 1¼ in. thick, and, say, 5 in. pitch; from ⅜ in. down to ¼ in. plates, the rivets may be ⅝ in. diameter and 3½ in. pitch.



44. GIB-HEADED KEY

Keys. A key is, strictly speaking, a *wedge*, and is used for securing cranks, wheels, pulleys, etc., upon their shafts. Figs. **41** to **43** illustrate the three principal types of keys. Fig. **41** is termed a hollow or saddle key; its holding power depends simply upon the friction established between it and the shaft; needless to say, it can only be used for light work. Fig. **42** is a flat key, and has a definite flat surface cut upon the shaft; it is consequently much better than the saddle key. Fig. **43** is the most generally used key, and is termed a *sunk key;* it is the strongest form, as it must either be sheared through, or tear a piece of the shaft out before failure. Where necessary, keys are made with a head [**44**], in order to facilitate withdrawal; they are then termed *gib-headed keys.* Heavy wheels, etc., upon large shafts, are frequently fitted with two keys placed at right angles to each other.

The proportions of the keys illustrated may be taken as follow:

$B = \frac{1}{4} A + \frac{1}{8}$ inch.

$C = \frac{3}{8} B$ $\qquad D = \frac{1}{2} B$

$E = \frac{5}{8} D$ $\qquad F = \frac{3}{8} D$

Feather Keys. Feather keys, although so termed, are not really keys in the true sense of the word—*i.e.*, they are not wedges—they are simply parallel pieces fitted into a groove in the shaft; they prevent relative circumferential movement, but permit definite end play, either in the shaft or in the piece feathered thereon. They are used chiefly for sliding clutches and pulleys.

Continued

A SHORT DICTIONARY OF TERMS USED IN DRAWING

ANTIQUARIAN—A drawing paper 52 in. long by 31 in. wide.

Atlas—A drawing paper 34 in. long by 26 in. wide.

Arrow Head—Crows' feet [*q.v.*].

square having its 30°, 45°, or 60°.

-Trammels [*q.v.*].

-Wholes and

Process—Ferro-gallic process [*q.v.*].

Blue Print—Ferro-prussiate process.

Border—Finishing lines around edge of drawings or tracings with or without ornamental corners.

Bordering Pen—Special drawing pen for borders.

Bow Compass—Medium size com-

CABINET NEST—A nest of superimposed palettes fitting into each other.

Calculating Rule—Slide rule [*q.v.*].

Cartridge Paper—A strong, cheap drawing paper.

Centre Line—A line drawn through the centre of a piece of work; used as a basis for measurements.

Chinese Ink—or Indian ink; used for inking in drawings and tracings.

Chinese White—Used for marking white lines on blue prints, etc.

Chords, Scale of—A means by which an angle can be laid off by taking compass measurements from the scale.

-A drawing paper 34 in. in. wide.

s—Instruments used for ng circles.

Compass Scale—A short metallic scale let into a T-square or scale for taking measurements by compass.

Continuous Paper—Paper supplied in roll instead of cut standard sheets.

Copier—An electric copier [*q.v.*].

Copying Frame—A frame in which tracings are copied or photographed.

Cross Section—A transverse section of an object or piece of work.

Crows' Feet—Angular lines ; used to indicate the limit of a dimension line.

Curves—Railway curves [*q.v.*], French curves [*q.v.*].

Cursor—The metallic slider upon a slide rule.

DATUM LINE—The horizontal base line from which heights and depths are measured.

Demy—A drawing paper 20 in. long by 15 in. wide.

Detail Drawing—A drawing which fully delineates one or more portions of a machine.

Dimension Line—A line which indicates the extent of a dimension.

Dividers—A form of compass with plain points used for dividing a line into a number of equal parts.

Dotting Pen—A drawing pen with a device to produce a dotted line automatically.

Double Elephant—A drawing paper 40 in. long by 27 in. wide.

Drafting Machine and Table—See text, pages 2788-9.

ELECTRIC COPIER—Machine for producing phototypes by electric light.

Emperor—A drawing paper 72 in. long by 48 in. wide.

Engine Divided—The marking of a scale or rule by a machine or engine.

FERRO-GALLIC PROCESS—A phototype process producing black lines on white ground.

Ferro-prussiate Process—A phototype process producing white lines on blue ground.

Flexible Curves—Strips of steel or other suitable material with attachments at intervals for deflecting and holding to any desired curve.

French Curves—Fancy curves of varying radii.

Fully Divided Scale—A scale divided throughout its length into its minimum division.

GENERAL DRAWING—A drawing which shows a machine entire.

Graphic Method—A method of determining a factor or a dimension by drawing instead of by calculation.

HAIR DIVIDER—A fine screw adjustment fitted to the leg of dividers to obtain exact measurements.

IMPERIAL—A drawing paper 30 in. long by 22 in. wide.

Irregular Curve—French curve [*q.v.*].

KNIFE KEY—A steel implement which combines screwdriver, penknife, file, etc., for adjusting instruments, sharpening pencils, etc.

LENGTHENING BAR—An extension bar used with large compasses to increase their radius.

MEDIUM—A drawing paper 22 in. long by 17 in. wide.

Metre Scales—Used for making drawings to metrical dimensions.

Mounted Paper—A paper mounted upon linen to give it strength and durability.

NAPIER COMPASSES—A folding compass for the pocket.

Needle Point—A compass point consisting of an ordinary needle held in place by a screw, and consequently easily renewable.

ODONTOGRAPH—A combination scale to facilitate the marking out of wheel teeth.

Oxgall—Used occasionally with inks and colours to make them work freely.

PALETTES—Ware receptacles for mixing colours.

Paper Scales—Scales engraved upon stout paper or Bristol board, convenient for measuring curves.

Parallel Rule—A straightedge or rule fitted with parallel joints or milled rollers to facilitate the drawing of parallel lines.

Photo-print or Phototype—A copy of a tracing produced by the action of light upon a sensitised paper.

Pillar Compasses—Folding compasses for the pocket forming a set of instruments.

Plan—A drawing of an article or piece of work viewed directly from above it.

Planimeter—An instrument used for computing areas.

Pricker—An implement with a needle point; used for pricking through centres and curve outlines where the paper is too opaque for tracing.

Printing Frame—A glazed frame used for phototype printing.

Proportional Compasses—Double-ended dividers with adjustable fulcrum, used for reproducing dimensions at any predetermined proportion.

Protractor—A scale, usually circular, which has the degrees of a circle marked thereon.

RAILWAY CURVES—Regular curves usually made in sets, and varying from $1\frac{1}{4}$ in. to 240 in. radius.

Retree Paper—Slightly defective sheets of paper.

SECTION—A view of an object cut through in order to show its construction and interior.

Sectional Elevation—A sectional view of an object as looked at from its side or end.

Sectional Colours—Various colours recognised as representing various metals and materials.

Sectional Paper—Paper ruled in squares to scale either English or

Sensitised Paper—A chemically prepared paper for photo-printing.

Set Square—A sheet of vulcanite, pear wood, etc., cut to form a right angle with two of its edges, the third edge being 30°, 45° or 60° angle

Single Reading Scale—A scale which reads from one end only.

Slide Rule—A rule with a sliding portion, engraved upon a logarithmic basis, to facilitate calculations.

Slope—A batter [*q.v.*].

Spring Bows—A small pair of compasses which maintain their full radius by reason of their spring formation; the radius is reduced by drawing the legs together by a screw.

Squared Paper—Sectional paper [*q.v.*]

Standards—Regular proportions of machine details which are tabulated for reference.

Stencils—Used for numbering drawings, corners for borders, etc.

Straightedge—A flat strip of wood with an accurately finished edge for drawing straight lines.

Stress Diagram—A diagram drawn so as to represent stresses graphically.

Sun Copy—A phototype [*q.v.*] printed by daylight.

Super Royal—A drawing paper 27 in. long by 19 in. wide.

TAPE—A continuous band of linen or steel coiled in a leather case, and engraved in feet and inches, etc.

Template—A piece of paper or cardboard cut to the exact outline of an object, to facilitate manufacture.

Tracing—A reproduction of a drawing on a transparent paper or linen.

Tracing Frame—A frame holding a sheet of glass, used to trace old drawings and prints which are best seen through the tracing paper when the light strikes from beneath.

Tracing Linen—or cloth, a prepared transparent linen for tracings.

Tracing Paper—A prepared transparent paper for tracing.

Trammels—A straight bar upon which slide movable heads carrying pen or pencil points, for striking large radii.

Triangular Scale—A scale of triangular section having six working edges and a great number of scales.

T-square—A piece of mahogany or pear wood with a head piece in the form of a T, used for producing parallel lines, and as a base for set squares.

Ticks—Crows' feet [*q.v.*].

UNIVERSAL SCALE—A scale upon which all ordinary scales are marked in parallel rows.

VERNIER—A short scale made to slide along a graduated instrument, for measuring very small intervals.

WHEEL PEN—A drawing pen with wheels for dotted work.

Wash Brush—A large brush used for extensive surfaces, etc.

Wholes and Halves—Compasses fixed at the proportion of one to two.

PREPARING FOR TANNING PROPER

The Processes of Bating, Puering, and Drenching. Tanning Materials. Tan Pits and Tanning Liquor

By W. S. MURPHY

Bating. The process of bating consists of steeping the goods in a weak fermenting infusion of pigeon dung, or poultry manure, for a period of from four to six days, and is adopted for heavy dressing and harness leathers, kips, and calfskins. Bate liquor, as may well be imagined, is a putrefactive agent, designed to act as a solvent on the hardened cement fibres of the leather, precipitating the lime, and softening the substance of the skin. The bate liquor, made of pigeon dung, or poultry manure, is made up in proportions of six to thirty parts of dung to one thousand of water. Having been infused in warm water, and allowed to ferment for a week, the clear liquor is poured off the dung into the bate-pit.

When the hides are soft to the feel, and begin to take on a bluish tinge, they are lifted out. The filthy character of the dung bate, and the uncertainty of its action and variability of composition, has led many manufacturers to seek out effective substitutes. One of the best is derived from coal-tar, and named the "c.-t. bate." The manufacturers give the following directions for its use:

1. After unhairing and fleshing from the lime, the skins should be thoroughly washed with water (preferably warm), so as to remove as much lime as possible.

2. If, in the liming process, the sulphide of sodium is used in combination with the lime, it will render the lime more soluble, and therefore more easily removed with water.

3. The more completely the skins are cleansed with warm water, the less will be the quantity of bate required.

4. After washing, the skins should be thoroughly worked on the beam, especially on the grain.

5. A solution of c.-t. bate is now prepared, in the proportion of from ½ lb. to 1 lb. of bate in 100 gallons of warm water (90° F.). In making the solution do not have the water over 140° F. Under no circumstances boil it.

6. If the hides or skins have been treated as above indicated, 1 lb. of bate should be sufficient for 400 lb. wet hide, washed from the limes. The hides or skins are placed in the bating solution, and worked for an hour. They are then allowed to rest in the solution, with occasional stirring, for some hours, or over-night.

7. The length of time that the bating should continue will depend upon the degree of softness and pliability required in the leather. For instance, for sole-leather, fifteen minutes is sufficient; for satin-leather, thirty minutes; for glove-leathers, four to six hours, or even longer.

8. On removing the skins from the bating solution, it is sometimes desirable, especially for the finer grades of leather, to wash them in warm water, and again work them over the beam. They are then ready to be placed in the tanning liquor.

9. In preparing the bating solution for the second pack, draw down the old solutions one-third, and replace with fresh water; then add in solution just one-half the quantity of bate used at first, and so on with each succeeding pack.

10. When fresh limes are used towards the end of the liming process, and a manure bate is deemed necessary to reduce the harshness of grain caused by the fresh lime, it is very beneficial to give the skins from the manure bate a drench of c.-t. bate, thereby arresting the bacterial action of the manure bate, preserving the grain, besides cleansing, bleaching, and neutralising the skins preparatory to laying them in the tanning liquor.

11. Again, when it is considered desirable to use a manure bate, it is a good practice to treat the skins as above indicated (down to item 7), and then place them in the manure bate. By this previous treatment the antiseptic action of the c.-t. bate tends to arrest the destructive bacterial action of the manure bate, thereby lessening the risk of damage to the grain. In all cases where the value of the leather is dependent on the quality and perfection of the grain, this is an important advantage to gain.

No doubt there is an element of unscientific assertion in the foregoing; but the directions are good counsel, whatever kind of bate be used.

Puering. Very similar to bating, both in action and application, *puering* utilises dog's dung instead of poultry manure, and is applied to lighter leathers, such as glove-kids, glacé kids, and morocco skins.

Some authorities pretend that it is the stomachic juices in the dog's dung that are the active agents in puering. We would fain hope some definite conclusion were come to on the point, for then we would be in sight of an efficient substitute. But even now authorities disagree alarmingly among themselves, and any conclusion on the part of practical men would be rash. Dog's dung very readily putrefies if exposed to the air, and the best method of preserving it is to mix the fresh dung with water, forming a paste, and to store in air-tight tanks till required. The dung should be allowed to ferment at least a week before using.

No fixed rule is given for quantities, nor can there be, because of the variable composition of the material. With dung of average quality, a puer mixture of milky consistency will contain sufficient active agency for the puering of two hundred lambskins. In cold weather the water should be at a temperature of from 60° to

may be raised as high as 77° F. The time required is determined by the weight and density of the skins. Slender, slink skins may be done in two hours, while heavier skins have been known to take over twelve hours. The skins are laid flat in the liquor, stirred and paddled for about thirty minutes, till they have been thoroughly soaked, and then allowed to lie for the full maturing of the process.

Artificial Puer. Though far from absolute certainty, the chemists of the leather trade have arrived at a practical solution of the puer difficulty, and Mr. J. T. Wood, in England, and Messrs. Popp & Becker, in Germany, succeeded in producing a very satisfactory artificial puer named *erodin*.

We quote these particulars from the directions for use given by the manufacturers :

For 100 lb. wet skin washed ready for bating, about 1 lb. of erodin is required. Or, in the metric system, 1 kilo wet skin requires about 10 grm. erodin. The strength or concentration of the bate must not fall below 3 grm. per litre of bate liquor—*i.e.*, ½ oz. per gallon.

For preparing the bate a sufficiently large cask or tub carefully cleaned and steamed out is placed near the bating paddle. The cask should be fitted with a steam pipe easily screwed on and off, and also furnished with a clean cover.

The requisite quantity of erodin is weighed out and put into the tub with fifty times its weight of water, and the whole brought up to a temperature reaching, but not exceeding, 40° C. (104° F.), by direct admission of steam, thoroughly stirred, and the pure culture of *Bacillus erodiens* added to the mixture. The temperature must not be allowed to fall below 25° C. (87° F.), and a little steam should be admitted first thing in the morning, again at noon, and in the evening, to bring the temperature up to 40° C. (104° F.).

A practical mode of procedure is as follows: On Friday make up and start fermenting twice as much erodin as will be required for a day's work. This is allowed to remain under the above-mentioned conditions until Monday. On Monday, half the amount will be used for bating ; this is replaced by an equivalent amount of fresh erodin powder, dissolved in fifty times its weight of water, which is added to the already fermented erodin in the tub. Proceed in this way each day until the following Friday, when there will be left in the tub sufficient erodin for one day. This is put into a smaller tub for use on Saturday, and the cycle of operations is repeated.

One pure culture of *Bacillus erodiens* should be used for every 11 lb. erodin powder, or less quantity.

Suppose the amount of erodin required for a day's work to be 11 lb. (5 kilos), then on Friday 22 lb. (10 kilos) erodin must be mashed as above described in 110 gallons (500 litres) of water, two pure cultures added, and allowed to ferment till Monday.

On Monday half of this is used, and to the remainder 11 lb. (5 kilos) erodin and 55 gallons (250 litres) water is added. This is repeated on Tuesday, Wednesday, and Thursday ; and on Friday half is used, and the remainder put in a separate cask for use on Saturday, and in the mashing cask a fresh quantity of 22 lb. (10 kilos) erodin with 110 gallons (500 litres) water is made up for use next week. On Saturday the remainder of the old mash is used up.

In case this mode of procedure is for any reason not suited to the conditions of work, erodin may be used by making up every day a fresh quantity with fifty times its weight of water, adding the pure culture, and allowing it to ferment three days before use.

This substance is coming more and more into general use, both in England and on the Continent. It has the advantage of being chemically composed, and therefore regular in its action. On the whole, with its obvious drawback of being a warm puer, erodin may claim to be an effective substitute for dog's dung.

When sufficiently puered, the skins should have a silky feel on the grain side, with a rather slippery touch ; if pressed between the finger and thumb, the impression is dark, and flesh and adhering matter slide off at a mere touch.

Drenching. Sometimes leather manufacturers make drenching a substitute for bating or puering on calf-kid ; but the more general practice is to drench after either of these processes, for the purpose of thoroughly freeing the skins from lime, and, in some cases, making them less flaccid. Drench liquor is produced by an infusion of bran made with hot water, fermented by two bacteria, named *Bacterium furfuris* (*a* and *b*), which develop acetic and lactic acids.

The bran should first be washed free from surplus fatty matter ; the washing at the same time causes the flour to adhere to the grain. In practice, the composition of the drenching liquor is varied according to the weight and thickness of the pelts.

An average drench is made of five parts of bran to one thousand parts of water, ranging about 10 per cent. of the weight of the batch of skins. If the drenching is meant to be slow, the temperature of the liquor should be 50° F. ; but for quicker action and thicker hides, a higher temperature is necessary. Take a freshly prepared drench, add a small quantity of old liquor to promote fermentation, and lay in the skins. Fermentation soon begins, and the evolved gases permeate the skins, making them rise to the surface. As the skins come up, they should be drowned again, till minute blisters begin to form on the grain, and then they must be taken out quickly. This is a rough rule, and sometimes leads to trouble, because the blisters sometimes suddenly appear and burst without warning, making pin-holes in the skin.

Experienced workmen know by the feel of a skin when the drenching has gone far enough, and it is to be feared that no very safe rule can be given on a basis of theory. When sufficiently drenched the skin folds easily without a crease, and appears white and soft. By careful testing, the exact point of sufficiency can be readily gauged in practice.

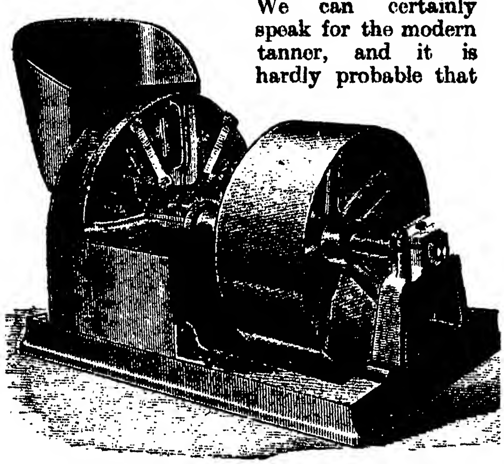
The Tanyard. The tanyard is still the heart of the leather industry. Here in those deep pits work the preservative agents that combat the forces of decay. An old tanyard is a place almost venerable, a kind of temple dedicated to the regeneration of animal matter. The pits range in rows full of watery liquor ; the men, clad in heavy leggings and aprons of leather, wield long hooks ; the hides are huge and weighty, and flop from pit to pit like

and raw materials are abundant ; and the men are alone.

The Tanner. It is admitted that the leather industry seemed to stand still for several centuries, but no one is entitled to infer from that a lack of intelligent appreciation in the tanner of the mystery and dignity of his craft.

Perhaps the very strangeness of the element with which he worked so strongly impressed the olden-time tanner, that he felt afraid to venture on interference. Here, he might say, is a decaying hide, decaying in spite of washing and liming, and by putting it among this tanning liquor I can make it immortal, impervious to decay, the

fit cover of the Eternal Word, or the lining of the coffer that holds the king's crown. No man works amid marvels so evident without reflection. Perhaps the tanner's reverence had the best of all practical issues—the resolve to use the mystery nobly and produce honest work. We can certainly speak for the modern tanner, and it is hardly probable that any class of manufacturers contains so large a proportion of men so deeply concerned in the quality of their product. We have seen tanners, men of wealth and culture, scanning the half-tanned hide under the microscope, and handling the finished "butt" with as much pride as the most ardent artist could bestow upon his most finished work. This is the spirit which can be bred in the tanyard, the impulse every true workman may feel if he be alive to the wonder of his craft. It may be that the centre of the battle between the tanner and the forces of putrefaction is moving from the rough arena of the tanyard to the scientific laboratory, that the swish and plump of the hides in the hands of strong men will give place to the powerful roll of machines; but for many years yet the tanpits will remain a rough and healthy discipline for the tan-worker, and after that a stirring recollection, like the memory of battles won by sword and spear. The leather manufacturer must always remember that his product does not go into the hands of an undiscerning public, but into the workshops of the expert, whose trade depends largely on the quality of his raw material.



4 BARK MILL (Joseph Hall & Co., Leeds)

Tanning Materials. Tannic acid is a vegetable acid secreted in the bark and leaves of numerous trees, and supposed by botanists to be a protective developed by the tree against the attacks of insects. Chemists are constantly enlarging our supply of this important material, discovering tannic acids in various vegetables hitherto unsuspected of containing the agent. But, as our object is immediately practical, we shall confine ourselves to those materials in general use.

Oak Bark. This is the oldest, most abundant, most commonly used of tanning agents. The common English oak gives the best tanning results, yielding about 18 per cent. of tanning matter. Young and coppice oaks, being juicy, give the best bark, though felled oaks, with the wood matured, are stripped of their bark by the application of steaming, the softened bark producing an average of 14 per cent. of tanning matter. Oaks grown on rich warm soils give the best barks. Cut in the early spring, when the living juices are rising, the healthy bark shows a bright red flesh inside. When dried, the inner coating turns a pinky red. If the skin be dark, the quality of the bark is inferior.

Valonia Oak. Abundant in Asia Minor and Greece, the valonia oak (*Q. Ægilops*) yields a rich tanning liquor, especially suited for tanning sole-leather. The source of the tanning agent is the fruit which ripens between July and August. After being beaten off the branches, the acorns are left on the ground to dry. In a week or so the gatherers come and put them into bags, in which they are borne to Smyrna. Here the acorns are stored in cellars and allowed to ferment till the nuts fall out, leaving the cups. When the fermentation has separated all the non-tannin parts, the valonia is carefully picked over, and the bulk separated into three qualities —first, second, and third. The second quality is that mostly sent to England, the difference between it and the first being merely in the smaller size of the cups. On the average, the tanners of the United Kingdom import annually 24,000 tons.

Chestnut Oak. America produces its own tannins, and the most valuable is the product of the chestnut oak, a tree closely allied to our own oak. The bark yields a strong infusion, and in general may be used as an efficient substitute for English oak.

Hemlock Fir. This is the principal tanning material of the American tanner. Though not so fertile in tannic acids, yielding about 10 per cent. as compared with the oak yield of 23 per cent., the tree is very abundant, easily grown, and early productive. The bark is smooth and yellow within, coated with a greyish rough epidermis, and contains a good quality of tannin.

Sicilian Sumach. Sumach ranks as, perhaps, the very oldest of tanning materials. The extract is derived from the leaves and small twigs of a scrubby bush, native to Sicily, where the growing of the plant is a regular industry. The plants are propagated by small suckers from older bushes, and set in the ground in rows about two feet apart. When a year old, the plants are ready for cutting and gathering. Leaves and twigs are separately dried and ground. Palermo is the centre of the trade, and thence it is shipped all over the world. For pale colour and soft tannage, morocco, roan, and skivers, sumach is the best material yet known, and produces leathers of bright tint and almost indestructible quality. Light and gas fumes affect sumach-tanned leathers in no degree. That material is, therefore, employed by tanners of binding and upholstery leathers.

Virginian and Australian Sumach. The late Professor Trimble discovered in Virginia, U.S.A., a small plant, named in botany *Rhus. glabra*, with qualities kindred to the sumach,

the leaves of which, on analysis, were found to contain about 20 per cent. of tanning material. On this a considerable industry has been built up in Virginia. About the middle of July the leaves are gathered, dried, and ground. Virginian sumach, though stronger in tannic acid, lacks the fine quality of Sicilian, producing a yellowish leather in contrast to the pure white of the latter. Australian sumach has all the fine qualities of the Sicilian variety, being produced from suckers of that plant; but as yet the trade is small, and therefore the tests have not been very thorough.

White Birch. Common birch bark is used for tanning sheep and goat skins in various northern countries—notably Scotland, Norway, Sweden, and Russia. The most important use of the birch bark, however, is the production of the tarry oil which gives to Russia leather its peculiar odour and insect-resisting power. When distilled, the birch bark gives off an oily substance which, when treated with petroleum ether, becomes the well-known Russia leather oil.

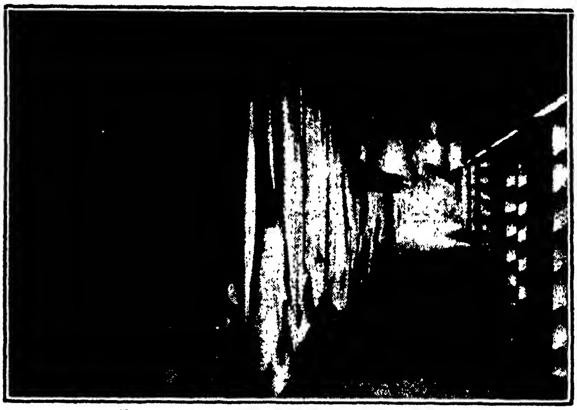
As we have said, the sources of tannic acids are manifold; oak galls, poplar bark, willow bark, roots of docks and palmettos, and various kinds of nuts in various forms, raw, ground in a bark mill [**4**], and prepared, are employed in tanning, and all with a certain measure of success, the value of each being mainly dependent on commercial considerations. Roughly speaking, if a tanner finds he can get the same tannage value out of a cheap willow as he can out of a dear oak bark, he will use the former till the latter is reduced in price.

Soles and Belts in the Tanpits. The object of tanning is to isolate the fine fibres of the hide and to sterilise that fertile albuminous matter which in life connects the fibres. The agent of this is the combination of chemical matters, practically named tannin or tannic acid, and present in the bark of oak, oak chestnut, and birch, and the fruit of valonia. We have seen the hides and skins come through the various processes by which they are prepared for tanning. Sole and belt leather hides have been let off lightly in those preliminaries, and now suffer the consequence. Few tan-

Tanpits. The tanpits are ranged in rows, and the series is divided into three—the suspenders, the handlers, and the layers. The suspenders for the complete deliming and breaking-in of the hides to the tanning liquor, the handlers for the gradual process of tanning with stronger and stronger liquor, and the layers for the complete saturation of the hides with the utmost quantity of tannin they will carry.

The Tanning Liquor. Oak bark is seldom used by itself, for it is dear, and a large quantity is consumed in the work; but, for the sake of simplicity, we shall consider it alone. A practical tanner first prepares his tanning liquor. Leaving aside the analysis of barks, the grinding and other preliminary processes, which scarcely belong to the tanyard, we look first at the *leaches*. This is a series of water-filled pits in which the liquor is prepared. By means of a false lattice floor, the tan bark is prevented from silting under the water. After the bark has lain a considerable period in the leach, the liquor is run off into the next leach, adding its strength to the liquor already there, and so on through the series till a strong liquor is obtained. But there is another method of obtaining strong tanning liquor. When the hides have passed through the handler pits, they are put in the layers, so named because as each hide is put in a layer of fresh tan bark is spread over it. A tanning liquor of great strength is thus developed in the layer pits. Now we are ready.

Tanning. Hides are of varying thickness, thickest on the back, and thinning out towards the belly, the loins, and the neck. To concentrate the tanning liquor on the "butt," as it is called, the thin parts are cut away and left over to be treated as dressing leather. Having been cut, the butts are hung perpendicularly in the suspenders—pits with a watery liquor, doctored, perhaps, with boric acid to assist in the precipitation of the lime remaining in the hide. After hanging in the suspenders for about two weeks, the pack is moved into the oldest and weakest of the series of eight pits we have named handlers



5. SKINS DRYING AFTER TANNING
(From a photo in Elswick Leather Works, Newcastle)

The pack lies in this pit a very short time, and when it is lifted out the pit is emptied and filled with strong liquor fresh from the leaches, or layers, or both. From the next strongest pit the hides are lifted and put into this fresh one, and the young pack shifted down to the next weakest, the series of packs being shifted up one. In this way the hides pass from stronger to stronger liquor in slow gradation, and at last arrive at the layers, in which they lie any period, from two months to two years, after which they are dried in a loft [**5**].

Continued

continued from p. 2875

TRYING ON & FITTING

The "Skeleton" and "Forward" Bastes. Important Points in Fitting a Garment. Errors and Alterations. Waterproofing

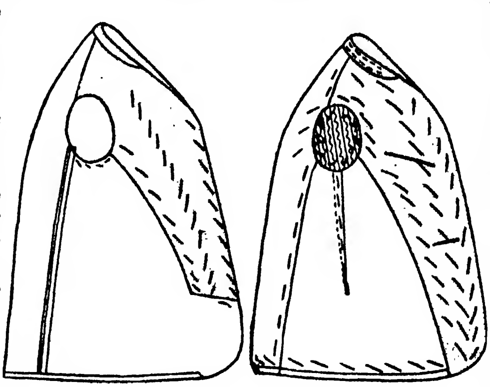
By W. D. F. VINCENT

THERE are several methods of preparing a garment for trying on, but as a rule one of two styles is resorted to. These are known as the "skeleton" baste [**25a**] and the "forward" baste [**25b**].

In the former the various seams are basted together, the canvas is put in the fore parts, one sleeve basted in, and sometimes a piece of canvas is put on to do duty for the collar. This plan is very defective, as it does not convey, either to the cutter or the customer's mind, any proper idea of what the garment will be like when finished. No seams are sewn, no manipulation is done, and no linings are in.

In the latter style the shoulders and fronts are both worked up, the seams are sewn with the exception of the back or the under-arm seam, the shoulders and the scye, the first row of sewing is put in, the edge and the linings are basted over, both sleeves basted in, and the collar basted on but not covered. This necessitates more work being put into the garment before it can be tried on, but as it is nearly all work that stands, it is not labour wasted.

Fitting. The first thing to note in trying on a garment is that it is properly on. This requires some little care; owing to the scye seams not being opened the armhole is smaller than it will be when finished. The garment being properly on, the first thing to note is the balance. If it hangs away at the back, it is too long in the front. If it stands away in the front it is too short in the front. If the balance is not correct, rip shoulder seams and adjust it to the customer's needs, then proceed to pin the fronts together and note the size. Place the two front edges together, and pin it up as shown on Fig. **28**, and then proceed to note the various points in the following order:



(a) (b)

25. "SKELETON" AND "FORWARD" BASTE

1. The top of back, including the height of collar. 2. The back scye, including the top of side-seam. 3. The waist at back and sides. 4. The bottom of the back and sides. [Points 1 to 4 are illustrated on **26**] 5. The balance of the sleeve. 6. The width of the sleeve at the elbow and cuff. 7. The length of the sleeve. [Points 5 to 7 are indicated on **27**] 8. The shoulder and front of scye. 9. The height of buttoning and the lapel. 10. The waist at front. 11. The bottom of the front [**28**].

Having noted these points, find out your customer's ideas on the various points and arrange for finish.

Alterations. Alterations are never attractive, but if customers are to be consulted, then alterations are sure to occur. They arise from errors in size and shape.

Errors in Size. A garment may be either too long or too short, too wide or too narrow. In shortening jackets, trousers, etc., the alteration must be done at the bottom, otherwise it will affect the depth of scye and, in the former case, the natural waist length, and, in the latter, the body rise. In dealing with sleeves it may be desirable sometimes to shorten equally at top and bottom in order to avoid getting the elbow too low.

In lengthening there is generally only one place to do it, that is where the inlay has been left. There are, however, one or two artifices that are helpful with certain garments. For instance, sleeves may be lengthened by putting on cuffs, and vests by putting in new backs. The body rise of trousers may be lengthened by dropping the fork and making up the length of leg by the inlay at the bottom. In increasing or reducing the width of a garment that is made up, it is generally done at the under-arm seam, adjusting the armhole as far as possible; and if the alteration is only a moderate one it answers fairly well. If, however, the alteration is extreme it will be necessary to adjust the neck point, otherwise the alteration will be too local.

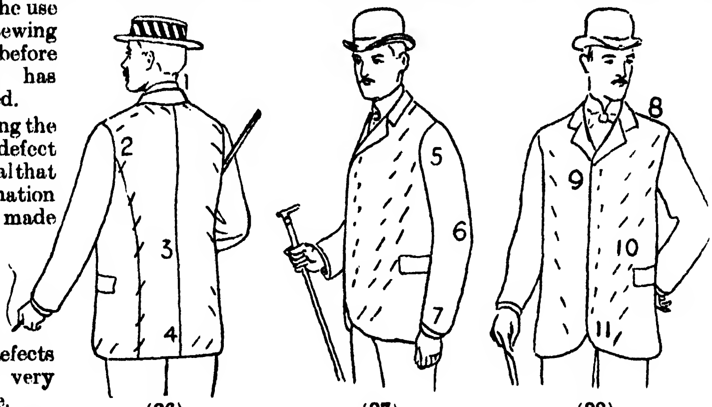
Errors in Shape. The total length and width of a garment may be correct, but the size may not be properly distributed, thus there may be too much room in the back, and too little in the front, and vice versâ. These defects show themselves in folds and creases.

Folds indicate an excess of material in the reverse way to which they run, thus horizontal folds indicate excess of length perpendicularly. Perpendicular folds are the result of excess of width horizontally. Creases, on the other hand, are the result of a lack of material in the direction in which they run—as, for instance, creases from neck point to front of scye, which are caused by a shortness at the neck point, which must be lengthened. Fulness, or loose material, is generally due to a tightness at some surrounding

part, as in the case of fulness at the top of side seam in lounges, which is frequently caused by too much suppression taken out of the waist.

Twisted seams are caused by the upper and lower layers of the material not being put together fairly, the one being kept tight whilst the other is fulled on; this result is often brought about by the use of the sewing machine before the seam has been basted.

In deciding the cause of a defect it is essential that an examination should be made of the surrounding parts, as different causes produce defects that are very much alike.



(26) (27) (28)

26–28. FITTING A COAT

If it is a case of tightness, note the direction of the strain. If folds, observe the way they run. If fulness, examine for tightness of surrounding parts. If twist, observe the direction of the twist.

TIGHT SCYE. If arising from lack of room from centre of back, let out at under-arm seam. If caused by shortness from nape of neck to bottom of scye, let out shoulder point or deepen scye. It may also need a larger sleeve.

FULNESS AT TOP OF SIDE SEAM. If produced by a too long back, pass back up at shoulders and neck. If by badly put in sleeves, rip out the sleeve at that part, draw in the back scye, and keep the sleeve in close, disposing of any fulness there may be right at the bottom of the scye. If by too much hollow at waist, let out side seam at that part. If by tightness over the seat, let out at that part. If by too short a collar, lengthen the collar or put on a new one.

FULNESS AT FRONT OF SCYE. Crooken the shoulder and take a V out at front of gorge.

CREASES ACROSS THE FOREARM OF SLEEVE. Lower forearm, or raise the front pitch and lower the hind arm pitch.

TIGHTNESS ON TOP BUTTON. Crooken the shoulder, and, if necessary, let out under-arm.

FULNESS AT TOP BUTTON. Straighten the shoulder and, if necessary, take in under the arm.

FULNESS AT FORK OF TROUSERS. Reduce width at bottom of fly seam, and take in at top of leg seam.

STRAIN FROM FORK TO KNEE. Let out at top of leg seam and, if possible, crooken the seat seam.

HORSESHOE FOLDS IN TROUSERS. Rip side seam and leg seam, and keep under side on tight at both leg and side seams for 10 in. or 12 in. down from fork, and full on a corresponding amount over the calf.

Waterproofing. Many garments are now made up from shower-proof cloth. It is common with tailors to send the garment to be waterproofed after the seams are sewn, etc., but before it is finished. There is no doubt this plan is much better than the old styles of macintosh, which were not only cold and uncomfortable but very unhealthy. The perfect ventilating qualities and the superior appearance of the waterproofed cloth give it a great advantage.

As a general rule, tailors send the garment to the wholesale woollen warehouse to have it waterproofed as far forward in the making up as possible; and as this is invariably done and returned within two days, they seldom trouble to do it themselves, especially as the charge made is very low. Still, it may be advantageous to be able to do this, and so we will describe the process. Dissolve a quarter of a pound of powdered alum, and rather more than a quarter of a pound of sugar of lead, in three gallons of clean water, stirring it twice daily for two days; then, when it has become quite clear, pour it off and add to the clear liquid two drams of isinglass which has been previously dissolved in warm water. Ensure this being thoroughly mixed, and then steep the garment in it for five or six hours, after which hang it up to drain and dry it carefully, avoiding wringing. Garments treated in this way are shower-proof, and will keep out a considerable quantity of rain.

How to Test Cloth. If cotton is suspected, the simplest plan is to dissolve all the wool; this may easily be done by putting a piece of the material into a solution of caustic potash and letting it boil for a short time. If the reverse operation is desired—*i.e.*, to destroy the cotton—it may be done in this manner: Soak it in dilute sulphuric acid standing at 4° Baume, for half an hour, then take it out, rinse, wring, and dry it in a place where the temperature is 180° to 200° F.

If it is desired to remove silk, it may be slowly dissolved by concentrated zinc chloride made neutral by boiling with zinc oxides. These are a few things out of many in which the chemist can help the tailor.

Tailoring concluded

THE VALUE OF ALCOHOL

Surgical and Medicinal Uses of Alcohol. Its Food Value and Reactions. The Aldehydes. Acetic Acid and Vinegar

By Dr. C. W. SALEEBY

NEXT to water, alcohol is the universal solvent. It is invaluable as a solvent of varnishes, and, indeed, there are very few organic substances which are not more or less soluble in it. We may note alkaloids, volatile or essential oils, resins, iodoform, besides many other newer medicaments. Many of these organic substances are contained in plants and have a medicinal value. Thus a very large number of drugs are administered in the form of alcoholic solutions or tinctures. Modern chemistry, however, has largely advanced beyond this stage and is able to extract from such tinctures the active principle which they contain. Such active principles can then be administered alone, with great advantage on the grounds of accuracy, purity, precision of dosage, and ease of administration, the sole disadvantage being that of expense.

Alcohol an Antiseptic. Since alcohol is, in general, what we call a protoplasmic poison—that is to say, a substance which is deleterious to all forms of life—it is, of course, an extremely valuable antiseptic, and, as such, has certainly been used for ages. The classical instance of the use of alcohol in what is now called antiseptic surgery is, we think, the parable of the Good Samaritan, who, finding the stricken Jew by the wayside, "went to him and bound up his wounds, pouring in oil and wine" (Luke x. 34). Even at the present day alcohol is not infrequently used by the surgeon as a basis for various soaps for the purification of the patient's skin and of his own hands. It is also used in order to preserve various surgical materials. In the form of methylated spirit, it has long been employed as a preservative for dead snakes, pathological specimens, and so on. It has been used as an antiseptic in internal medicine; but it is one of its properties, when highly concentrated, to interfere with the action of the ferments of the stomach just as, after a certain point, it arrests the action of the ferment secreted by the yeast that produces it. Thus its medicinal value on this particular score is probably negligible. The explanation is that the alcohol precipitates the pepsin or ferment of the stomach.

Vinegar and Obesity. Perhaps the importance of the subject will excuse us for referring to the only fashion in which acetic acid is nowadays employed internally in medicine. This is done only by extremely foolish girls or other people who are afraid of becoming stout, and, instead of applying the most elementary chemical knowledge to the problem, which would naturally induce them to lessen the amount of oxidisable matter they consumed and to increase the opportunities for the oxidation of what remains, proceed to dose themselves with vinegar, which they have been told is a remedy for obesity. Now, it is true that the drinking of vinegar will lessen weight, and it is also known precisely how it acts. It is worth while to explain this, not only because it may afford a warning of practical importance, but also because we may contrast it with the behaviour of certain other organic acids and organic salts, which have an extremely interesting action of a most unexpected kind, but capable of complete chemical explanation, when they are introduced into the blood. The drinking of vinegar reduces the weight of the foolish patient because it sets up a mild inflammation of the coat of the stomach and thus acts as a check upon the absorption of the food. It will be obvious that, of the many foolish things that people do for the sake of appearances, this is an example that can defy most competition.

Action of Similar Substances. If, however, we turn our attention to such salts as the acetate of potassium, which is without the local irritant action of acetic acid, or if we take such examples as citric acid, such as occurs in oranges and lemons, limes and citrons, we find that these substances do tend towards the reduction of the bodily weight. It is a general proposition in physiological chemistry that the rate of oxidation—or, to use a more general term, of what physiologists call *katabolism*—varies directly as the alkalinity of the blood and the bodily fluids in general. Any substance, therefore, that makes the blood more alkaline tends to increase oxidation of superfluous fat, and so to counteract obesity; on the contrary, any substance which reduces the alkalinity of the blood will tend to lessen the rate of oxidation and so to increase the accumulation of fat. If the blood be not alkaline, and definitely so, life cannot continue; "acidity of the blood" has no existence, but the alkalinity of the blood may be *more or less marked*. What, then, will be the effect upon the blood, and therefore upon the rate of oxidation in the body, of drinking a glass of lemonade? The inevitable answer would seem to be that the alkalinity of the blood would be lessened and oxidation retarded. Somewhat paradoxically, however, precisely the reverse is the case. Citric acid, its salts the citrates, the acetates, and other similar organic acids and their salts actually increase the alkalinity of the blood, because they do not circulate in the blood as such; nor does citric acid, for instance, neutralise part of the bicarbonate of sodium in the blood and thus lessen the alkalinity of that fluid. On the contrary, the citrate thus formed—and the same is true of similar salts—is known to be

oxidised by the oxygen present, in the form of what we have recently referred to as HbO_2, or oxy-hæmoglobin, in the red blood corpuscles. The consequence of the oxidation is to convert these salts into definitely alkaline *carbonates*. Hence, the ultimate result of taking such acids as that of the lemon is to *increase* the alkalinity of the blood and therefore the rate of oxidation in the body and the dissipation of any oxidisable material such as fat that may have accumulated in too great measure.

Local Actions of Alcohol. But alcohol has some other local actions in relation to living matter, these being dependent on its physical and chemical properties. It evaporates with extreme quickness whenever it is exposed, and thus, if it be applied to the skin, it has a marked cooling property, the transformation of the alcohol from the liquid into the gaseous form necessitating its absorption of heat or kinetic energy, according to the principles with which the student of physics has become familiar. On the other hand, the physical properties of alcohol may be differently used. For if it be applied to the skin and prevented from evaporating, its physico-chemical affinity for water manifests itself; it absorbs water from the tissues around it, and thus hardens them. It has the common action upon all living tissues of extracting water from them. Whereas it is a solvent for a very large number of organic bodies, it coagulates or solidifies albumin if it is able to act in strengths of 60 per cent. or upwards. Lastly, we may note as a contact or chemical action of alcohol upon living tissues, that after stimulating the nerves of sensation it slightly weakens their sensibility; in other words, it is a weak local anæsthetic.

In quite recent times, to have stated this last fact, for instance, would have been regarded as an intrusion in a course of chemistry. Indeed, it may be questioned whether there is any chemical textbook which contains it. But facts like these afford a very curious instance of the way in which science is injured by being divided into compartments.

The New Science of Pharmacology. The present writer has taken the trouble to go through all his books dealing with the action of drugs upon the body, on the one hand, and, on the other hand, all his books on chemistry. In the first series of books the action of alcohol on the nerves—which we merely take as an instance—is noted and left as a sort of ultimate fact. There is no suggestion that it has any chemical significance. In the chemical books, on the other hand, it is not alluded to at all. The chemist thinks it outside the province of chemistry, and the students of drugs act as if they thought it needless of explanation. This is very bad indeed for both sciences. Of course we are far from asserting that the leading experts keep these two subjects apart in their minds as if they were unrelated; but, at any rate, the student is left to find out for himself that they are related—that, in fact, there are not sciences but Science.

All over the world men and women are now studying the action of chemical bodies upon the various tissues and structures that are found in the living bodies of animals and plants. This new science is known as *pharmacology*. Its practical importance in medicine is, of course, obvious. Plainly, the doctor is more likely to use his drugs wisely in disease if he knows their action in health. It is from this point of view that pharmacology is commonly regarded. For instance, as we have seen, medical men ought to know, as everyone does know, that the local application of alcohol has a soothing action upon irritable tissues.

But, more widely considered, this practical aspect of pharmacology is seen to be a very small matter. When we come to think more consecutively, we see that pharmacology is really a new and immeasurably complex chemistry; but there is no domain of chemistry which promises to be more fruitful. Suppose, for instance, that it could be shown that the activity of the nerves depends upon a physico-chemical change in the albuminous matter of which they are composed—as in all probability it does—and that the action of alcohol, like that of so many other substances, in first stimulating and then depressing the activity of the nerves, could be shown to depend upon its precipitation of this albumin or these albumins; and suppose that this property of alcohol in this particular instance could be found to fall into line—as not improbably it does—with its action upon other living tissues (which all contain albumins), so that in one single statement there could be summed up a chemical explanation which would cover both the action of alcohol on the brain and its action upon the living cells of some humble plant—plainly this would be science of a very high order.

Chemical Substances and Living Tissues. This, indeed, is the kind of science which is now dawning. The chemist must not be allowed to ignore, as if they were non-existent or uninteresting or non-chemical, the remarkable chemical interactions between innumerable chemical substances and living tissues, which are themselves chemical complexes; nor, on the other hand, must the medical student or biologist be allowed to study chemistry in his first year of study, pass an examination in it, cast it behind him, turn to the study of pharmacology, learn the action of alcohol upon nervous tissue—and never for a moment suspect that this is none other than a higher chemistry for which the other was a preparation.

There are quite a number of chemical substances which pharmacologists are coming to rank as *protoplasmic poisons*. Protoplasm, as the reader knows, is the name applied to the complex of chemical compounds which is regarded as the "physical basis of life" (Huxley), alike the life of a bacterium or the life of the body of man. It is of the utmost interest to discover that there are certain substances, such as antimony, arsenic, alcohol, chloroform, carbolic acid, prussic or hydrocyanic acid—to name only a few out of a great host—which seem to interfere with the processes of living matter, to thrust a spoke into the wheel or cycle of its chemistry wherever it is found. Such facts must rouse our scientific

interest. We are compelled to ask ourselves, in each case, what is the chemical explanation? We cannot help suspecting that it is one and the same explanation for the whole series of living forms when affected by a given substance—as, for instance, let us suppose, the interaction of alcohol and albumin, wherever albumin is found, or the action of alcohol upon the water which is present in all living tissues. Whether or not we are able to reduce the facts to a definite chemical explanation, they teach us, as their chief lesson, the common character, the essential unity of protoplasm everywhere, so that, no matter where it occurs, a drop of prussic acid or alcohol or chloroform will form a definite reaction with it, just as hydrochloric acid and sodium carbonate or carbon and oxygen have definite relations with one another at all times and all places.

Opinion versus Science. It is partly in order to insist that the whole of pharmacology is really a special province of chemistry that we have made this digression, but partly, also, in order to give prominence to the fact that the pharmacology of alcohol, or the results of its chemical relationships to the various tissues and organs of the human body, is not nowadays a matter for individual experience or for mere opinion, but is a matter to which science has devoted very great attention for the last twenty years, and on which the most important and precise conclusions have been reached. These conclusions are of the utmost importance—individual, national, racial, and even ethical. Unfortunately, this is not yet generally recognised; it is not known that there is, so to speak, a science of alcohol; still less are its conclusions common property. Hence, extremists or biassed persons of all shades of opinion are able to promulgate whatever doctrines suit their creed or purse or temperament. It is in order to remedy these evils that a company of experts is now preparing a book which, it is hoped, will put an end to the prescientific stage of the discussion of alcohol.

A very large number of details in the pharmacology of alcohol are as yet incapable of a chemical explanation, and, therefore, in this place they must be ignored. But some of the most important of the properties of alcohol are strictly referable to chemical conceptions. It is, indeed, a very great pity that even the barest allusion to these should be lacking in the ordinary chemical textbooks.

Alcohol and Temperature. For instance, it has long been known that alcohol reduces the temperature of the body. This it does in various ways, as, for instance, by sending a lot of blood to the surface, where it warms the nerves of heat and makes us think we are warm, whereas, of course, we are losing heat as fast as possible by radiation and conduction. But the most remarkable manner in which alcohol lowers the temperature is by interfering with oxidation in the body. This oxidation depends upon the properties of the red colouring matter in the blood, which, as the reader knows, is called *hæmoglobin.* For convenience this is symbolised by the letters Hb. As this Hb passes through the lungs, it becomes oxidised, forming a loose but definite chemical compound which is called *oxy-hæmoglobin,* and may be symbolised by the formula HbO_2. We dogmatically assert that this is a true compound because, when we examine venous and arterial blood by means of the spectroscope [see PHYSICS], we find a definite and constant difference between the spectrum of the hæmoglobin in the one and the oxy-hæmoglobin in the other. There can be no more final proof that the oxygen has formed a compound with the hæmoglobin in the case of the arterial blood. We know, of course, that this compound has a brighter colour. The whole value of HbO_2 in the economy is that it is a readily decomposed compound, very easily giving up its oxygen for the purposes of the life of the tissues. Now, it has been clearly proved that alcohol increases the stability of HbO_2, with the consequence that the tissues are relatively starved of oxygen. Quinine and prussic acid have similar actions upon this compound. In the case of the latter, the decomposition of the oxy-hæmoglobin is absolutely arrested, and death ensues from what is, in effect, none other than suffocation. The continued ingestion of considerable quantities of alcohol tends to interfere so definitely with the oxidation of the bodily tissues that the oils or fats of the body accumulate and the patient becomes the subject of a morbid stoutness. On the other hand, in cases of fever, the administration of considerable doses of alcohol may be extremely valuable in lowering the temperature by the means we have described.

Oxidation of Alcohol. And this leads us to a new and still more interesting aspect of the subject. Everyone knows that alcohol burns. We students of chemistry know, *à priori,* that it *must* burn, because we know its composition. In each molecule of alcohol there is already merely one atom of oxygen, which may satisfy the desires of two atoms of hydrogen in C_2H_6O, leaving four atoms of hydrogen and two of carbon unoxidised, and therefore combustible. Now, alcohol is not, of course, oxidisable at the ordinary temperatures of the air. It does not undergo what is rather stupidly called *spontaneous combustion.* Just as in the case of coal or wood, one needs first of all to raise the temperature very considerably by means of a flame, and then the oxidation will occur—itself producing a temperature high enough to permit of its own continuance.

The probability, then, would appear to be that alcohol cannot be oxidised in the body, which, after all, has a temperature not so very much higher than that of the atmosphere. But, on the other hand, other factors than temperature may induce the oxidation—presumably, as will have occurred to the thoughtful reader for himself, by providing those unknown conditions which are necessary to oxidation and to the production of which high temperatures owe their power of inducing it. We must not, then, answer this question as to the oxidation of alcohol, even at the comparatively low temperature of our bodies, without using the experimental or *à posteriori* method.

Has Alcohol a Food Value? Our inquiry has an obvious chemical interest, but it has a very great human interest as well. This will be evident if we consider for a moment what is meant by a food. As the reader knows, food is a substance which either forms tissue or provides the body with energy—a substance which does neither may be a tonic, or a stimulant, or a poison, but not a food. Thus, in inquiring into the food value of alcohol, we can lay down certain definite propositions. The first is that its chemical characters absolutely exclude it from any possibility whatever of belonging to the higher order of foods—those which form tissue. Alcohol is not a constituent of protoplasm, and is not capable of being even utilised as a "brick" or ingredient in the making of any constituent of protoplasm. But, on the other hand, alcohol, in virtue of its chemical characters, is capable of oxidation if the conditions be favourable. We already know that the oxidation of carbon and hydrogen, as in a fire, yields kinetic energy in the forms of heat and light. The so-called chemical or potential energy of the elements involved has been transformed into kinetic energy. If, then, we can burn up alcohol in the body, the oxidation of its carbon will similarly evolve kinetic energy which will yield heat or motion, or, in other ways, will serve the needs of life by providing the conditions which permit of its continuance.

Food and Poison Too. Now it has been definitely proved that alcohol is capable of oxidation within the body, and the conditions and limits of this oxidation can be stated with considerable definiteness. In general, it may be said that the ingestion within twenty-four hours of 1½ oz. of alcohol will result in complete oxidation, provided that this very small quantity be taken in fractions at sufficiently frequent intervals and in much dilution. If these conditions be granted, no alcohol can be recovered; all has become oxidised and destroyed. It is quite evident that this small quantity, and the conditions under which it has to be taken for complete oxidation, correspond to the practice of only a very few persons. But whether it corresponds to common practice or not, the fact remains that alcohol may rank as a food with the qualifications stated. It is a food because it is oxidisable in the body.

The most powerful arguments may be adduced in favour of the proposition that alcohol is unique in being a food and a poison as well, like the sea-water, which may be used in a marine engine, but will ultimately ruin it. This we add because it is not just merely to state, without such a qualification, that alcohol may have a food value. It may be noted that alcohol is sometimes extremely valuable as a food when other food is insufficient. On the other hand, it is unnecessary when other food is sufficient, and is, beyond all question, toxic when other food is more than sufficient—as is the general rule with prosperous people in this country.

Alcohol owes its value as a food in cases of fever, for instance, to a unique property which it possesses in requiring no primary digestion. All other foods require to undergo chemical changes in the stomach and bowel before they can be absorbed into the blood. Such chemical changes, which are in the main very simple, are called *digestion* or *primary digestion*. It is only after this process has been completed that the food is available. Now, in fever, for instance, primary digestion is greatly interfered with, and this is where alcohol comes in. It requires no primary digestion, but is absorbed into the blood unchanged, and by purely physical processes which are independent of the health of the digestive organs, and can therefore be utilised when everything else fails. It will allow life to continue for several days with no other aid, and in desperate cases nothing else can compete with it.

Alcohol and Nervous Tissue. Perhaps even more remarkable is the fact that a high temperature of the body markedly increases the proportion of alcohol that can be oxidised within it. Thus, in fever, one may give, for instance, 10 oz. of alcohol in a day, the whole being oxidised. The remarkable fact in such cases is that the alcohol, when it is demanded as a food by tissues which may be receiving no other food, is prevented from acting as a stimulant so-called. The consequence is that during fever a man may receive, oxidise, and utilise, without any nervous or mental symptoms whatever doses of alcohol which, if his temperature were normal, would produce the most marked and violent intoxication.

For some chemical reason, which is as yet obscurely understood, alcohol has a greater affinity for nervous tissue than for any other. After death it is much more readily found by chemical tests in nervous tissue than elsewhere, and it is an extremely remarkable fact that when the most delicate tests fail to reveal the presence of alcohol in any other part of the body, it can readily be detected in the fluid which circulates through the nervous system.

We take the opportunity of quoting from the greatest living authority, Professor Metchnikoff, the world-famous discoverer of the functions of the leucocytes, or white cells of the blood. In his lecture before the Royal Institute of Public Health, May 25, 1906, occurs a passage which we translate from the original French:

"Alcohol, therefore, suppresses the natural immunity of rabbits towards the first vaccine of anthrax. This impairment of their resistance was manifested by the inactivity of their white blood cells; thus the bacilli were permitted to multiply without being checked by a sufficiently strong phagocytic ('eating cell') reaction. As has been established, the leucocytes are sensitive even to small doses of ethylic alcohol, and present a negative sensibility in the presence of this substance. Alcohol, therefore, has a harmful action on the agents of natural defence against infective microbes."

Tests for Alcohol. The most commonly employed test for alcohol is the iodoform test, which consists in the formation of yellow crystals of iodoform when alcohol is exposed

to the action of iodine and caustic potash. A few crystals of iodine should be added to the fluid under examination, together with just enough caustic potash to decolourise the iodine. If the test tube now be heated, iodoform crystals will appear. Another common test is the chromic acid test, the addition of a small crystal of the red bichromate of potassium, together with heat or sulphuric acid, yielding a green colour due to the formation of the chromate. These tests and various others must be combined, as no one of them is conclusive singly.

Amyl Alcohol. The only other member of the series of alcohols to which we need refer here is *amyl alcohol.* It is, of course, ethyl alcohol, which we have been discussing some time back, but for convenience we dropped the specific name. The formula of amyl alcohol need not be again quoted. It is obviously the hydroxide of pentane, as ethyl alcohol is the hydroxide of ethane. The substance which usually goes by the name of amyl alcohol is really a mixture of two closely allied alcohols which are so nearly identical that they have the same formula. During the process of the rectification of ethyl alcohol, there is left in the stills the product which is called fusel-oil. This consists mainly of the two forms of amyl alcohol and also of propyl and butyl alcohols. The amyl alcohols have an apple-like odour, an oily appearance, and are only very slightly soluble in water. They are extremely poisonous, and in even moderate doses produce violent convulsions together with mental disorganisation.

General Reactions of Alcohols. We have already emphasised the fact that the alcohols are a series which has a systematic and uniform character. For convenience we may return to ethyl alcohol which, as usual, we shall simply call alcohol, and we shall find in it an adequate illustration of the behaviour of the other members of the series to which it belongs.

If alcohol be oxidised totally, as when a flame is applied to it, the products are, of course, carbonic acid and water. But it may be oxidised to a measure short of this, and so may its fellows. For instance, by various means one atom of oxygen may be added to one molecule of alcohol, with the result that two atoms of hydrogen are removed so as to form with the thieving atom a molecule of water. When alcohol has thus had two atoms of hydrogen removed from it, it is alcohol de-hydrogenised, and a short name has been coined to express this conception of it. Hence we have the word *aldehyde,* the three syllables of which exactly express the process by which an aldehyde is formed. In short, an aldehyde is a de-hydrogenised alcohol.

Other Members of the Alcohol Group. But the process may go further. Yet another atom of oxygen may be inserted into the aldehyde, but in this case it does not thieve away two atoms of hydrogen, but finds a home for itself in the molecule, forming the compound known as *acetic acid.* The following table gives the sequence in the case of the first two members of the series of paraffins:

Paraffin	Alcohol	Aldehyde	Acid
CH_4 Methane	CH_3OH Methyl Alcohol	$CHOH$ Formaldehyde	$CHOOH$ Formic Acid
C_2H_6 Ethane	C_2H_5OH Ethyl Alcohol	C_2H_3OH Ethyl Aldehyde	C_2H_3OOH Acetic Acid

etc., etc.

In the above we have not attempted to give the various formulæ in their more complex and instructive form. On the contrary, we have written them merely in such a fashion as to express in the simplest way the manner in which each of these stages is derived from the last. The reader will surely be impressed by the orderly and intelligible character of this part of our study, especially if he remembers that the above table deals merely with the first two lines of an indefinite number, each displaying the same orderly character.

At this point the reader might well amuse and instruct himself by trying to construct, whether from memory or from "intelligent anticipation," the graphic formulæ of the eight substances of which formulæ more or less constitutional are given above.

Formaldehyde. The new substances which occur in the above table are all of them of very considerable interest. Perhaps formaldehyde is the most interesting of all, because it seems to afford a clue to certain of the most important stages in the cycle of life. It is plain that from one point of view formaldehyde might be looked upon as CH_2O. Directly we write the formula in this fashion we say to ourselves, Why, surely this is the simplest carbohydrate! Does it not answer to the definition of carbohydrates upon which we have already agreed—substances, the molecules of which consist of carbon, hydrogen, and oxygen, the two latter being present in the proportions in which they occur in water? Now this leads us much further. We know that carbohydrates are formed by plants; we know, furthermore, that they owe their existence in the plant to the activities of the green leaf. We know that under the influence of sunlight the leaf obtains nascent and elemental carbon from the carbon dioxide of the atmosphere. We know also that the plant always obtains abundance of water from the soil. Is it not, then, conceivable that the plant unites the nascent carbon with water to form methyl aldehyde or formaldehyde, which is, so to speak, the unit of the various carbohydrates which afterwards appear in the plant—sugars, starches, and so on? May we not imagine that, for instance, six molecules of formaldehyde might be packed together so as to form a single molecule which, of course, would have the formula $C_6H_{12}O_6$, the formula of glucose?

A Suggestion to Remember. This is an extremely interesting, probable, and suggestive speculation, and should certainly be remembered by the reader. Its value is not in the least detracted from by the necessary qualification that, in the form in which we have stated it, it is somewhat too simple. Doubtless, for instance, when we write the formula of glucose or of any other carbohydrate, we ought

to enclose the whole formula in brackets, and then append an *n* in order to indicate that we do not know how many times over these combinations of atoms must be taken in order really to constitute a molecule of the substance in question. This and similar qualifications are necessary, but the reader should always look upon methyl aldehyde as a substance which has a unique speculative interest attached to it.

But even so, it cannot be dismissed, for we shall find that it is of the very greatest practical interest. Methyl aldehyde or formaldehyde is a gas soluble in water. The aqueous solution is usually known as formalin, and contains from 35 to 45 per cent. of the aldehyde. It is an extremely powerful and penetrating antiseptic and is steadily coming more and more extensively into use for this purpose, and also as a substitute for alcohol in the preservation of specimens. In much greater dilution, formalin may be used as a mouth wash, and attempts of uncertain value have been made to utilise it as an antiseptic within the body in the treatment of various germ diseases, such as consumption.

Formic Acid. Our table has taught us that when methyl aldehyde is oxidised still further it yields formic acid, and at this point, perhaps, we shall find a clue to the name *formaldehyde*. Formic acid is so called because it occurs in considerable quantities in the body of the ant, the Latin name for which is *formica*. Its constitutional formula is best written HCOOH. Remembering the general rule as to the relation between successive paraffins, we shall then be able to see that the best way in which to write the constitutional formula of acetic acid will be to add CH_2 to the H of formic acid, which will yield us the formula CH_3COOH. This, indeed, is the formula of acetic acid. Formic acid is found not only in ants, but also in the stinging nettle, of which it is the actual weapon. Special interest, of course, attaches to it because it is the first of the series of acids which are called the *fatty acids*. It may be prepared artificially in many ways, the commonest of which is to heat oxalic acid with glycerine. Formic acid is a mobile liquid which resembles water in many of its physical characters—for instance, its boiling and freezing point and its specific gravity are all very close to those of water. Potassium formate may be made by a remarkably simple synthesis—that is, by the direct union of carbon monoxide and hot caustic potash. The reader will find that the formulæ of these two substances, added together, constitute the formula of potassium formate.

Aldehyde. Just as ethyl alcohol is usually called alcohol, so ethyl aldehyde is usually called *aldehyde*. Its constitutional formula is better written CH_3COH, or, still better, for the matter of that, H_3CCOH, since this last form shows us how the carbon atoms are united together in ethane and any of the substances derived from it. This ethyl or acetic aldehyde is a colourless, volatile liquid, the boiling point of which is 21° C., and the specific gravity ·78. It has a characteristic smell. It is an excellent solvent for various substances such as phosphorus. Aldehyde is most commonly prepared by the interaction of bichromate of potassium upon ethyl alcohol, which it oxidises, removing two atoms of hydrogen in the manner we have described. Aldehyde is by no means a stable body, since it undergoes oxidation on mere exposure to the atmosphere, with the formation of acetic acid.

Acetic Acid. The best way in which to write the constitutional formula of acetic acid is H_3CCOOH. Its relation to ethane and the intermediate bodies has already been stated, as also its relation to formic acid, the first member of the series of fatty acids. In considering the natural production of acetic acid, we find that we have to consider again a process of fermentation. The ethyl alcohol from which it was derived was itself produced by fermentation. If, now, another organism, called the *mycoderma aceti*, be allowed to act upon such alcoholic liquids as beer and wine, a new and further fermentation occurs. The reader will ask how this can happen if alcohol itself be, as we stated, an antiseptic. But it is only in very considerable concentration that alcohol is an antiseptic. The amount contained in a weak wine or beer is quite inadequate to protect itself from decomposition. This is why weak wines often have spirit added to them in order to make them keep. In consequence of the oxidation of the alcohol in a weak wine, there is produced practically a weak acetic acid, and this we usually call vinegar. The process of the manufacture of acetic acid varies in different parts of the world, according to the price of alcohol. If wine be cheap, acetic acid may be obtained from it by the deliberate conversion of wine into vinegar. The *mycoderma*, or vinegar-plant, is found in abundance on bundles of twigs, over which wine is made to run very slowly, with the practically instantaneous production of vinegar which, as might be expected, still retains a certain proportion of the flavour of the original wine. On the other hand, malt vinegar is prepared from beer which is made to flow between beech shavings, on which, again, the vinegar plant grows. In England, where alcohol is dear, acetic acid is commonly obtained by the dry distillation of wood. The acetic acid thus obtained is, of course, very impure, and is named, in allusion to its process of manufacture, *pyroligneous acid—i.e.*, "fire-woody." This requires to be freed from wood spirit, tar, and other impurities. The process is commonly performed by the addition of calcium carbonate, so as to form calcium acetate, which is heated, with the result that the tar adherent to it is disposed of, and then the acetate is decomposed by means of strong sulphuric acid.

Continued

FITTINGS FOR VEHICLE BODIES

Coach Ironmongery and its Fitting. Locks, Hinges, and Canopies. Provisions for Heating, Lighting, and Ventilation

By H. J. BUTLER

A FRENCH bodymaker in a large shop often confines himself to the woodwork of the body alone, leaving the fixing of the various pieces of metalwork to another workman. The British bodymaker, on the other hand, makes and fits his body ready for the painting.

Locks. A *lock* is generally understood to contain a dead bolt and to require a key to open it, while a *latch* is opened by the handle turning against the pressure of a spring, yet carriage builders are familiar with slam and lever *locks* which should strictly come within the other term. We are all familiar with the Yale lock in its several forms, and, as might be supposed, it is much used in America. In a vehicle such as a brougham the lock, being placed about the centre, is intended to "pull up" the door and so equalise the already natural bending at top and bottom—that is, if the door pillars have been properly marked out. In a landau [39] or landaulette we have no bearing at the door top, so our lock must be fitted below the elbow. Some builders still maintain that the fitting of a lever lift is obligatory in these vehicles so as to prevent opening the door while the glass-frame is in the pillar tops and so break it; but in a short time, with the almost universal adoption of the glass-frame carriers in motor landaulettes, their allegations that these carriers admit water and rattle will fall to the ground, from the overwhelming evidence of their opponents. The lever lift was designed so that when the door was closed and the glass-frame up, the latter rested on a metal plate on the fence rail. The door handle and this fence plate were connected, and the turning of the handle had the effect of lifting the frame into the door, not without sometimes coming down rather smartly, to the hurt of the door and to the frame itself.

Hinges. Foremost among this class is the *concealed hinge,* which is constructed to fulfil its duty so that, when the door is shut, it is hidden —hence the appellation. The fitting of these in broughams and landaus requires no little skill, even the mortising out in the standing pillars for their reception is no light task. We should endeavour to get the top hinge as high and the bottom one as low as possible, the lock being placed midway. Seldom is it necessary that three are wanted. Where there is much turn-under, an *outrigger hinge* is preferable, especially if folding steps are added that work with the opening of the door.

Butt hinges are used where concealed hinges are not justified by the selling price; and apart from that, they do not require such heavy timbers for their attachment. We see them introduced into motor-car bodies almost without exception. Butt hinges have many uses other than for carriage and car doors. The doors of cupboards, lids of lockers, the pivoting of windows and ventilators and folding tables are instances of their various uses.

Then there are *spring hinges* for swinging doors and the *step-ladder hinge,* which is also a safety hinge, allowing the ladder to open only to a certain stride.

Hanging Doors. In coach work, while the smith is fitting the edge or body plates it is a convenient opportunity to frame up the doors and box them out for the shut and hinge checks and glass runs. The making of landau, brougham, and 'bus doors demands great skill on the part of the workman, not only in making them fit the body, but in the nicety with which the hinges are adjusted and the lock let in, so that it shuts sweetly and goes truly home. It is rather difficult to describe just how a door should perform its function, but the experienced man can tell almost by the sound and the feel of the moving door as it shuts whether it has been hung faultlessly or not. As previously mentioned, a comparative large turn-under, as in landaus and omnibuses, necessitates an outrigger or long, projecting hinge. This is neutralised to an extent by having a long hinge at the top. In any case, whether butt, concealed, or outriggers are used by themselves or in combination, it is essential for the true working of the door that the pins on which the hinges work shall be all in the same straight line.

The hinges may be tried to the pillar with a retaining large tack or one screw and the positions when found scratched with an awl. Perhaps, at the first attempt, the door drops or is raised a little. This error must be carefully adjusted by paring at the hinge, and one often sees, if he notice closely, various forms of packing which have been utilised to remedy defects.

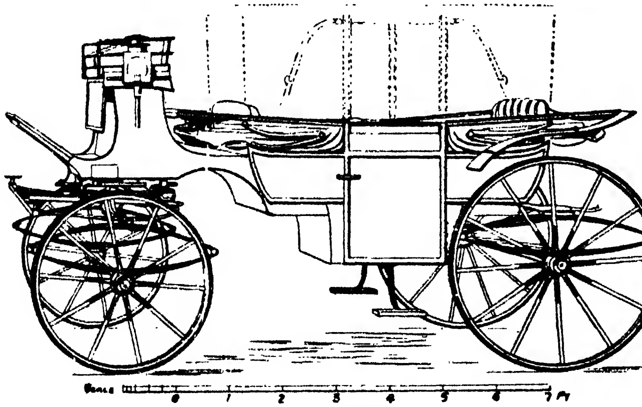
Folding Heads. In square [38], canoe, and posting landaus we have the double-folding head meeting in the centre above the doorway. To allow of folding, the pillars are cut at the top of the fence rail. Below this line we have a separate door pillar hinged to a standing pillar, but above the *pillar top,* as it is called, we have the two combined in one. The head leather is fixed to it, and the glass-frame run is also to be found therein, whereas in a brougham these two functions are located in separate pillars. The depth of the fence rail must be sufficient, so that when the pillar top and slats are folded down on the

hind prop it will lie about flat. Due allowance must also be made for the space taken up by the folding of the leather and head lining. The fitting of the pillar hinges should allow the pillar top, when down, to stand up above the top of the fence rail about the thickness of the wasting; some fall almost level, while other types bring the head much higher.

Head Mechanism. The folding pillars and door top are rabetted out for the glass-frame; and then it is found that we have several head mechanisms designed to raise and lower the head, among which may be mentioned the "Climax," the "Euston," and the "Universal." The glass-run in the pillar tops must be in the same straight line as in the door pillars, otherwise the frame will jamb. In cutting the door top on the bevel, we allow the front portion to be the smaller, so as to bring the boot as close to the body as possible. At the cut in the door top thimble catches or other fasteners are fixed to draw up the head when closed. The rain is kept out by the fixing of a weather plate.

The two centre hoopsticks are screwed to the door top, the others being attached to the centre and corner slats, which are themselves screwed to the neck plates of the pillar hinge.

In a victoria head [39] the head slats may be obtained ready bent in one piece. There is no hoopstick, the slat running from pillar to pillar. In some types of head mechanism it is possible to dispense with the outside joint, but in any case it is usual for the footman to have to step down from the box to raise or lower the head, as it is not considered dignified to stand up in the vehicle and effect the operation. In Cape cart hoods and the different forms of American heads, there are many ingenious and light-weight types of coverings. In England we do not see them much on horse-drawn vehicles, but their use is certainly popular all over the world for motor-cars and for the American type of road waggons. Leather is often dispensed with, and in its place we find various kinds of waterproof canvas which require only a very light structure of wood and iron to keep the hood in its place. These hoods are without mechanism. The double extension hood is arranged so that the front slats and irons are removable from their bearing and then lifted to the corresponding hind one, and both front and hind portions turned back together. Light is admitted to the back of this type of head by means of celluloid windows. Curtains to roll up form part of the equipment, and these also are made with transparent panels stitched in.



38. SQUARE LANDAU
Dotted lines show position of head when up

Canopies. The motor-car has also made us familiar with the canopy. It is practically a roof without the top side framing and panelling. In some instances the protection of the canopy is furthered by panelling the back and part of the sides. His Majesty King Edward VII., the Prince of Wales, Lord Londonderry, and others favour this type of protection in their automobiles. The canopy is usually supported on iron standards fixed to the body and dashboard. Often they are finished in brass. Canopies are also used in conjunction with glass screens, the one in front being often considered dangerous should it become fractured while driving, and in bad weather the rain makes the glass misty, and therefore renders a good view of the road in front impossible.

The screen immediately behind the chauffeur's seat is well designed when it is made in three sections, the central one hinging to allow the giving of directions to the driver, and the whole being made to hinge up into the roof when not wanted.

Curtain and Rails. Curtains of different materials are added to afford side protection, and may be made either to roll up or bunch round the standards. In the latter fixing they run on a rod fixed in the canopy.

A roof rail with or without a net gives great convenience in a touring car, and is a good place to carry a spare cover. Care must be taken in fixing that plenty of headroom is allowed in a long car, and that the shape of the canopy conforms to the contour of the body. It looks well when projecting both at the back and front. When well forward in front it protects the glass-frame over the dash from the weather when used — a remark that applies to extension heads. The canopy must be strongly fixed. Standards of good size and material should have long flaps, securely fixed, otherwise we have it swaying, a contingency met with more often than it should be.

In motor broughams, landaulettes, omnibuses, etc., we see a dash extension canopy used to protect the occupants of the front seat, and many think that it adds to the appearance of the car, as well as giving space for the disposal of baggage, which in a landaulette is a distinct advantage, as the roof cannot well be used for this purpose.

Other Canopies. It will be remembered that one of the first Thornycroft motor 'buses was provided with a canopy to the roof seats, no doubt owing to the smuts emanating from the end of the long chimney. In France the motor 'buses are so protected, thereby adding to the all-weather utility of the vehicles.

Tramcars in towns where the double deck types are used are fitted with canopies which are also enclosed with glass, many of the frames being made to drop.

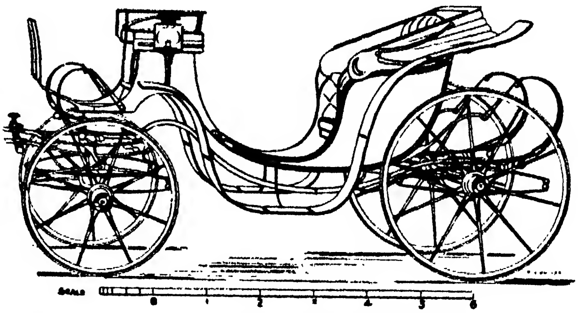
The Glasgow trams and the County Council trams in South London are examples. In foreign countries with hot climates we see merely an awning arranged. The tilts of vans are a means whereby the contents are protected from the elements and give a lighter superstructure than building a solid top. Bakers' barrows are often fitted with a roof cover when a load of bread is carried outside, thereby increasing the capacity.

Vehicle Carving. Royal carriages and those used by the nobility on grand occasions have in their decoration many evidences of the art of the woodcarver. The body mouldings and under-carriage woodwork generally is ornamented with well-designed and beautifully finished work. In an ordinary private carriage the dub end of the beds and pump handles and the carving on the boot brackets is an example of this branch of work.

There was a time when a coach carver could earn a good living by doing nothing else, but nowadays carving is not much used, and the bodymaker himself is often called upon to do what little is wanted.

In van-building there is perhaps more carving than is necessary on a vehicle that is intended for trade use and rough work. Still, brewers, market gardeners, and wine and flour merchants all seem to like plenty of it. *Shaving*, as it is called, weakens the structure, and we must be careful not to overdo it. Some of the railway and delivery companies exclude shaving from their vans almost entirely, and it must be admitted they appear more fitted for the purpose intended.

Ventilation. The passenger temporarily housed within a vehicle demands a supply of fresh air. In a railway train not only is there the breathing of one's fellow passengers, but the atmosphere of the tunnel and gases from the engine all tend to vitiate the air. Then in corridor trains there are the cooking stoves and the aroma from meal tables to contend with, and in all types of rolling-stock where smoking is allowed we must have good ventilation. Again, a sleeping car must be properly designed to keep up a supply of fresh air during the night. In our compartment carriages we are familiar with the drop window in the door. This provides at once plenty of fresh air, but often with the disadvantage of the force wherewith it is supplied, and generally with the accompaniment of smuts, especially if one is seated looking towards the engine and the wind is blowing towards the moving train. From its position it is also a cause of argument as to whether it shall be up or down, whereas if it did its work effectually without the probability of a strong draught it would be an ideal means of ventilation. We should seek to supply the required oxygen in a manner that will purify the enclosed atmosphere of the carriage or car gently yet thoroughly and persistently.



39. A CAB-BODIED VICTORIA MOUNTED ON A "C AND UNDER SPRING" UNDER-CARRIAGE

Types of Ventilators. An auxiliary to the drop window is the hit and miss ventilator above the door opening. Then in the roof are to be found various types of automatic or self-acting ventilators which are set in motion by the movement of the train. Here at home the torpedo type is familiar, while abroad there are various other forms, such as the cone and apron, Moore, duplex, Star, and Globe. Then the body is often constructed with a clerestory, which allows a current of air in the centre of the car above the heads of the passengers even when they are standing. Hinged ventilators are often placed in the clerestory. Sometimes the clerestory is known as the *deck*. The use of electric revolving fans has been tried with some success. One fan must be set to work to draw in the fresh air while another exhausts the bad air. It is useless to put in one fan, which merely stirs up the air. In tramcars we have the clerestory or deck ventilators, besides hinged frames in the front of the car. Then front sliding doors may also be opened if necessary, and in many cases the side windows are made to drop, slide, or hinge or slide up into the roof.

Omnibuses are not so well supplied with ventilation, there not being so much constructional convenience in the front for ventilation, although we may yet see improvements in side ventilation.

If builders are afraid of the rattling of dropping or sliding windows, there is no reason why the ventilating rail even on alternate windows may not be made lower than it is at present, so that a large upper portion of the side windows may be hinged down. Perhaps, with improvements in engines, we may be enabled to get the motor 'bus body lower on the ground and still keep the same over-all height, utilising the spare inches for giving more clear headroom inside and well ventilating the upper space.

The presence of side louvres and often front and hind louvres must not be forgotten. In

single-deck 'buses are to be seen types of self-acting ventilators as mentioned under railway vehicles. It is a regulation of the Metropolitan Police that a stage carriage shall be properly ventilated without opening the windows. Is it ?

Ventilation of Private Carriages. In carriages we have the drop glass-frame in the doors, drop and sliding lights in front, and sometimes, though rarely, a roof ventilator. These are found in broughams. Landaus have the usual door ventilation ; and often the glass-frame, as in other close vehicles, is itself ventilated on the top stile. The front and back light is often hinged, and then we have the side-light landau with its drop front quarter glass-frames. Private omnibuses have louvres, and the various glass-frames are made to drop or slide as the case may be. The various enclosed types of motor-cars have similar means of ventilation. The disposal of the glass-frames into the roof is a departure from the usual carriage practice, although, as mentioned, it is adopted in tram-cars. Also, there are various articles which reach their destination in a more marketable condition if the van or freight car be efficiently ventilated. We see self-acting roof ventilators and side and end louvres adopted in the conveyance of fruit, milk, and other perishable commodities. The refrigerator cars prove excellent means of keeping fresh many articles of food.

In vans and carts the rolling-stock of the butcher and fishmonger are instances where the same idea is carried out. The conveyance of livestock by road and rail also demands that the horses and other animals shall be properly supplied with fresh air during their journey.

Heating and Lighting. The foot-warmer has been condemned with many sarcastic allegations regarding its inefficiency. The American looks upon our historic hot-water can as a harmless joke. Still, we are now having our trains better heated by means of steam from the engine, and let us hope it will not be overdone, as it often is across the Atlantic. On a winter day, however, it is easier to lower the temperature of a heated carriage than it is to raise it. In America special apparatus for heating the cars, prominent among them being the Baker heater, are used. The heating is effected by the circulation of hot water, and the heater is usually placed in a small closet called the *heater-room*. This has interior heat guards, preventing all direct radiation. In the same part of the world cars carrying vegetables such as potatoes are, in winter, heated by special forms of mineral-oil lamps, the supply being automatically controlled by the expansion and contraction of metallic rods. Electric heating is adopted on the District Railway.

Perhaps in motor omnibuses we may soon see some system of heating the car, but the straw seen in some horse 'buses, and the mats in electric trams, are about all that conduce to a comfortable temperature on a cold day, unless we include the shutting out of all the fresh air. In private carriages we may have foot-warmers or any patent portable method of heating that may be purchasable, not to speak of warm clothing and

The English railway carriage has generally been lighted by means of an oil lamp inserted in the roof from above and inaccessible from within the compartment. Compressed gas and electricity are now more frequently used, and the dim light of the past is now being superseded by the brilliancy of the modern methods of distributing electric illumination. In the daytime it is still a fact that one may be suddenly called to travel through a fairly long tunnel or a series of tunnels in darkness. One cannot grumble at the light in our new tube railways. It is easy to read the smallest print, and the habit of putting the light so that it comes over one's shoulder as is seen in some first class carriages is to be recommended.

Whatever the system of lighting, it is far more convenient if each coach is independent in itself. This has been successfully carried out with electric lighting, the power being taken from the axles. In America the lamps, whatever the type, can be got at from the interior of the coach.

Forms of Lighting Appliances. The last car in a train is also fitted with the various forms of tail lights. The conductors, guards, and inspectors, each have their own lamps or lanterns. In mail vans special powerful lamps are provided to aid the correct sorting of the letters and parcels.

In trams and 'buses we have front and rear lights arranged in a box-like receptacle so that they give a coloured light forward (often denoting the route of the vehicle) and light up the interior from the other side. A similar plan is adopted in the hind light. Electric tramcars are provided with interior roof lights and one or two light the upper deck. Then there are the head lights and tail lights. Acetylene has been used in various vehicles for illuminating purposes, but faulty apparatus, and consequent leaking, besides unskilled supervision, has been the means of limiting its adoption. Some time ago a company had a good many acetylene lamps on the London omnibuses, but, apart from other reasons, the practice ceased from financial causes. The flavour of leaking acetylene is quite sufficient to promote its disuse.

A great many omnibuses are still partly lit by the oil lamp in the hind roof canopy. Gas has also been successfully used. Electric light in horse omnibuses has not been successful, owing to repeated failures and consequent summonses. All motor-cars are well lit, perhaps more than is judicious as regards the headlights of some large cars. Van lamps are used sometimes from legal necessity, and also to help the carman in the execution of his duties.

Continued

Group 21 **MATHEMATICS** 21 ALGEBRA continued from page 2894	# FRACTIONS **Algebraic Definition. Reduction to Lowest Terms. Reduction to a Common Denominator. Addition, Subtraction, and Multiplication of Fractions**

By HERBERT J. ALLPORT, M.A.

FRACTIONS

79. In Article **70** of Arithmetic we saw that to obtain the fraction $\frac{3}{7}$ we must divide a unit into 7 equal parts and take 3 of them. Similarly, *when a and b are positive whole numbers*, we obtain the fraction $\frac{a}{b}$ by dividing a unit into b equal parts and taking a of them.

It is clear that, with this definition, the values of a and b must be restricted to positive whole numbers; for there would be no meaning in the definition if a had such a value as -4, and b the value $\frac{2}{3}$. We cannot "divide a unit into $\frac{2}{3}$ equal parts and take -4 of them."

We must, therefore, find a definition for the fraction $\frac{a}{b}$ which will apply to cases in which a and b are not positive whole numbers.

Using the definition given, let us multiply $\frac{a}{b}$ by b. To do this we must take each of the a parts b times. This gives ab parts altogether; and, since each b parts make a unit, ab parts will make a units. Therefore

$$\frac{a}{b} \times b = a. \quad . \quad . \quad . \quad . \quad (1)$$

Hence we may take for our definition, *the fraction $\frac{a}{b}$ is the quantity which must be multiplied by b to obtain a.*

Divide both sides of the equation (1) by b, and we obtain

$$\frac{a}{b} = a \div b.$$

Thus, we may also define the fraction $\frac{a}{b}$ as *the quotient obtained by dividing a by b.*

80. As in Arithmetic, the whole theory of fractions depends on the following proposition.

The value of a fraction is unaltered when its numerator and denominator are multiplied by the same quantity.

We have already proved, in the last Article, that

$$\frac{a}{b} \times b = a.$$

Hence, multiplying both sides of the equation by m, we see that

$$\frac{a}{b} \times bm = am.$$

Thus, $\frac{a}{b}$ is the quantity which, when multiplied by bm, gives am.

But, by the definition of a fraction, the quantity which, multiplied by bm, gives am, is $\frac{am}{bm}$. Hence

$$\frac{a}{b} = \frac{am}{bm};$$

so that, for all values of a, b, and m, the value of the fraction $\frac{a}{b}$ is unaltered when we multiply both numerator and denominator by m.

81. We have proved that $\frac{a}{b} = \frac{am}{bm}$. But, if we divide both numerator and denominator of $\frac{am}{bm}$ by m we obtain $\frac{a}{b}$.

Thus, the value of a fraction is unaltered if we *divide* both numerator and denominator by the same quantity.

82. Reduction to Lowest Terms. A fraction is said to be in its lowest terms when the numerator and denominator contain no common factors. Hence, to reduce a fraction to its lowest terms, we must divide numerator and denominator by their H.C.F.

If the factors of the numerator and denominator can be easily found, the *common* factors are obvious, and can then be rejected. If the factors cannot be found by inspection, we find the H.C.F. by the rule of Art. **69**, and then divide numerator and denominator by the H.C.F.

Example **1**. Reduce

$$\frac{14x^2y^2z}{21xyz^3}$$

to its lowest terms.

The H.C.F. of the numerator and denominator is $7xyz$. Dividing the numerator by $7xyz$ we obtain $2xy$; and by dividing the denominator by $7xyz$ we obtain $3z^2$. Hence the given fraction is equal to $\frac{2xy}{3z^2}$.

Example **2**. Reduce

$$\frac{x^2+6xy-7y^2}{x^2+9xy+14y^2}$$

to its lowest terms.

Resolve the numerator and denominator into their simplest factors, and then reject those which are common. Thus

$$\frac{x^2+6xy-7y^2}{x^2+9xy+14y^2} = \frac{(x+7y)(x-y)}{(x+7y)(x+2y)}$$
$$= \frac{x-y}{x+2y} \quad \underline{Ans.}$$

Example 8. Reduce

$$\frac{x^3-5x^2-8x+12}{x^4-7x^3+7x^2-7x+6}$$

to its lowest terms.

In cases of this sort, before resorting to the H.C.F. rule, always try whether any factors can be found by the Remainder Theorem [Art. **65**].

In this example, the numerator vanishes when we put $x=1$. Hence $x-1$ is a factor, and we have

$$\begin{aligned} x^3-5x^2-8x+12 &= x^2(x-1)-4x(x-1)-12(x-1) \\ &= (x-1)(x^2-4x-12) \text{ [Art. **65**, Ex. **1**]} \\ &= (x-1)(x+2)(x-6). \end{aligned}$$

We have now simply to try which of these factors divides the denominator. We find, by substituting $x=1$ and $x=6$ that the denominator vanishes, but that it does not vanish for the value $x=-2$. Thus $(x-1)(x-6)$ is a factor of the denominator.

By actual division, $(x-1)(x-6)$, or x^2-7x+6 divided into the denominator, gives x^2+1 for quotient.

Or, the same result may be arrived at in a manner similar to that of Art. **65**, Ex. **1**. Thus

$$\begin{aligned} x^4-7x^3+7x^2-7x+6 &= x^2(x^2-7x+6)+(x^2-7x+6) \\ &= (x^2-7x+6)(x^2+1). \end{aligned}$$

Hence, the given fraction

$$=\frac{(x-1)(x+2)(x-6)}{(x-1)(x-6)(x^2+1)}=\frac{x+2}{x^2+1}\ \underline{Ans.}$$

EXAMPLES 23

1. $\dfrac{28a^2bc^2}{63a^4b^2c}$.
2. $\dfrac{12a^5b^2x^3y}{30ab^4x^2y^2}$.
3. $\dfrac{a^2-ab}{ab-b^2}$.
4. $\dfrac{x^4-x^2}{x^4+x^3}$.
5. $\dfrac{x^2-5x+6}{x^2+3x-10}$
6. $\dfrac{x^2-4x-21}{x^2-3x-18}$.
7. $\dfrac{1-2a+a^2-2a^3}{2-4a+a^2-2a^3}$.
8. $\dfrac{15a^3b+39a^2b-18ab}{10a^2b^2+6ab^2-4b^2}$.
9. $\dfrac{x^4-13x^2+36}{x^4-x^3-7x^2+x+6}$.
10. $\dfrac{8x^3-10x^2-16x-3}{6x^4-22x^3+31x^2-23x-7}$.

83. Reduction to a Common Denominator. We have seen [Art. **80**] that the value of a fraction is unaltered when we multiply both numerator and denominator by the same quantity. Hence a fraction can always be expressed with a denominator which is some multiple of its original denominator. It follows, therefore, that any number of fractions can be expressed with a denominator which is some *common* multiple of the original denominators. There is generally a saving of labour if we use the *least* common multiple.

The process is like that already explained for Arithmetic [Art. **77**, page 547].

Example. Reduce

$$\frac{1}{x-y},\ \frac{1}{x+y},\ \text{and}\ \frac{2y}{x^2+y^2}$$

to a common denominator.

The L.C.M. of $x-y$, $x+y$, and x^2+y^2 is $(x-y)(x+y)(x^2+y^2)$. Dividing the first denominator, $x-y$, into this common denominator, we obtain $(x+y)(x^2+y^2)$ for quotient. We must, therefore, multiply both numerator and denominator of the first fraction by $(x+y)(x^2+y^2)$. Similarly, we must multiply numerator and denominator of the second fraction by $(x-y)(x^2+y^2)$, and of the third fraction by $(x-y)(x+y)$. Thus, we obtain

$$\frac{1}{x-y}=\frac{(x+y)(x^2+y^2)}{(x-y)(x+y)(x^2+y^2)}=\frac{x^3+x^2y+xy^2+y^3}{x^4-y^4}$$

$$\frac{1}{x+y}=\frac{(x-y)(x^2+y^2)}{(x+y)(x-y)(x^2+y^2)}=\frac{x^3-x^2y+xy^2-y^3}{x^4-y^4}$$

$$\frac{2y}{x^2+y^2}=\frac{2y(x-y)(x+y)}{(x^2+y^2)(x-y)(x+y)}=\frac{2x^2y-2y^3}{x^4-y^4}.$$

84. Addition and Subtraction of Fractions. If two fractions have the same denominator, their sum or their difference will have that denominator. The numerator is formed by taking the sum, or the difference, of the numerators. The result must be reduced to lower terms, if necessary. Thus, the sum of the fractions $\frac{a}{a+b}$ and $\frac{b}{a+b}$ is $\frac{a+b}{a+b}$, which reduces to 1. The difference of the same two fractions is $\frac{a-b}{a+b}$.

If the fractions have not the same denominators, we first reduce them to a common denominator [Art. **83**] and then proceed as above.

Example **1**. Find the value of

$$\frac{1}{a-2}+\frac{1}{a+2}.$$

The L.C.M. of the denominators is $(a-2)(a+2)$. Hence,

$$\begin{aligned} \frac{1}{a-2}+\frac{1}{a+2} &= \frac{a+2}{(a-2)(a+2)}+\frac{a-2}{(a-2)(a+2)} \\ &= \frac{a+2+a-2}{(a-2)(a+2)} \\ &= \frac{2a}{a^2-4}\ \underline{Ans.} \end{aligned}$$

When there are several fractions, some of which are to be added, and some subtracted, the method is the same.

Example **2**. Find the value of

$$\frac{2}{x^2-1}+\frac{3}{x^2-4x+3}-\frac{4}{x^2-2x-3}.$$

The given expression

$$\begin{aligned} &= \frac{2}{(x-1)(x+1)}+\frac{3}{(x-1)(x-3)}-\frac{4}{(x+1)(x-3)} \\ &= \frac{2(x-3)+3(x+1)-4(x-1)}{(x-1)(x+1)(x-3)} \\ &= \frac{2x-6+3x+3-4x+4}{(x-1)(x+1)(x-3)} \\ &= \frac{x+1}{(x-1)(x+1)(x-3)}=\frac{1}{(x-1)(x-3)}=\frac{1}{x^2-4x+3} \end{aligned}$$

$\underline{Ans.}$

Sometimes it is better not to reduce all the fractions to a common denominator at once, as in the following example:

Example 3. Find the value of

$$\frac{1}{a-x}-\frac{1}{a+x}-\frac{2x}{a^2+x^2}-\frac{4x^3}{a^4+x^4}.$$

Taking the first two fractions we have

$$\frac{1}{a-x}-\frac{1}{a+x}=\frac{(a+x)-(a-x)}{a^2-x^2}=\frac{2x}{a^2-x^2}.$$

Next, take this result and the third of the given fractions, thus

$$\frac{2x}{a^2-x^2}-\frac{2x}{a^2+x^2}=\frac{2x(a^2+x^2)-2x(a^2-x^2)}{a^4-x^4}=\frac{4x^3}{a^4-x^4}.$$

Finally, the result just obtained, and the last fraction, give

$$\frac{4x^3}{a^4-x^4}-\frac{4x^3}{a^4+x^4}=\frac{4x^3(a^4+x^4)-4x^3(a^4-x^4)}{a^8-x^8}.$$

$$=\frac{8x^7}{a^8-x^8}\ \underline{Ans.}$$

85. We have defined the fraction $\frac{a}{b}$ as the quotient obtained by dividing a by b. But, by the rule of signs, the same result is obtained when we divide $-a$ by $-b$. That is,

$$\frac{a}{b}=\frac{-a}{-b}.$$

Hence, *if the signs of both numerator and denominator be changed, the sign of the whole fraction is unaltered.*

Again, the fraction $\frac{-a}{b}$ is the quotient obtained by dividing $-a$ by b. This quotient, by the rule of signs, is of opposite sign to that obtained by dividing a by b. That is

$$\frac{-a}{b}=-\frac{a}{b}.$$

In a similar way we see that

$$\frac{a}{-b}=-\frac{a}{b}.$$

Hence, *if the sign of either the numerator or the denominator be changed, the sign of the whole fraction will be changed.*

Example 1. Simplify

$$\frac{2}{x+y}-\frac{1}{x-y}-\frac{3y}{y^2-x^2}.$$

Here, the L.C.M. of the first two denominators is x^2-y^2. We therefore change the sign of the third denominator, and obtain x^2-y^2 instead of y^2-x^2. The working of the example then appears as follows:

$$\frac{2}{x+y}-\frac{1}{x-y}-\frac{3y}{y^2-x^2}$$

$$=\frac{2}{x+y}-\frac{1}{x-y}+\frac{3y}{x^2-y^2}$$

$$=\frac{2(x-y)-(x+y)+3y}{x^2-y^2}$$

$$=\frac{2x-2y-x-y+3y}{x^2-y^2}$$

$$=\frac{x}{x^2-y^2}\ \underline{Ans.}$$

Example 2. Simplify

$$\frac{a}{(a-b)(a-c)}+\frac{b}{(b-c)(b-a)}+\frac{c}{(c-a)(c-b)}.$$

Here, although there are apparently six different factors in the denominators, we notice that three of them are obtained from the other three by changing the signs. Thus $b-a$ is simply $a-b$ with the signs changed.

We therefore write the six factors in *Cyclic Order*, *i.e.*, we write them so that c always follows b, a always follows c, and b always follows a, thus $b-c$, $c-a$, $a-b$.

In the present example we see that, to bring about this arrangement, we have to change the sign of one factor of the denominator, writing $(c-a)$ instead of $(a-c)$, and so on. This, of course, changes the sign of the whole fraction. Thus the given expression

$$=-\frac{a}{(a-b)(c-a)}-\frac{b}{(b-c)(a-b)}-\frac{c}{(c-a)(b-c)}$$

$$=\frac{-a(b-c)-b(c-a)-c(a-b)}{(b-c)(c-a)(a-b)}$$

$$=\frac{-ab+ca-bc+ab-ca+bc}{(b-c)(c-a)(a-b)}$$

$$\therefore\ \frac{0}{(b-c)(c-a)(a-b)}=0\ \underline{Ans.}$$

EXAMPLES 24

Reduce to their simplest form

1. $\frac{x-y}{x+y}-\frac{x+y}{x-y}$. 2. $\frac{x-2}{3x+1}-\frac{x+2}{3x-1}$.

3. $\frac{1}{x+1}+\frac{2x}{(x+1)^2}-\frac{3x^2}{(x+1)^3}$.

4. $\frac{2x}{x+y}+\frac{2y}{x-y}-\frac{x^2+y^2}{x^2-y^2}$.

5. $\frac{x-a}{x+a}+\frac{x+a}{x-a}+\frac{x^2-5a^2}{x^2-a^2}$.

6. $\frac{2}{a^2+a}+\frac{2a-1}{a^2-a+1}-\frac{2a^3-1}{a^4+a}$.

7. $\frac{1}{1-x}+\frac{1}{1+x}+\frac{2}{1+x^2}+\frac{2}{1+x^4}$.

8. $\frac{1}{x-y}+\frac{2}{x-2y}+\frac{2}{x+2y}+\frac{1}{x+y}$.

9. $\frac{a-4}{a^2-5a+6}-\frac{a-10}{2a^2-5a-3}+\frac{a-7}{2a^2-3a-2}$.

10. $\frac{b+c}{(a-b)(a-c)}+\frac{c+a}{(b-c)(b-a)}+\frac{a+b}{(c-a)(c-b)}$.

11. $\frac{2+3a}{3-a}-\frac{2-3a}{3+a}+\frac{22a-3}{a^2-9}$.

12. $\frac{x(y+z-x)}{(y+z)^2-x^2}+\frac{y(z+x-y)}{(z+x)^2-y^2}+\frac{z(x+y-z)}{(x+y)^2-z^2}$.

86. Multiplication of Fractions. Let $\frac{a}{b}$ and $\frac{c}{d}$ be two fractions, and let x denote their product $\frac{a}{b}\times\frac{c}{d}$. Then

$$x\times b\times d=\frac{a}{b}\times\frac{c}{d}\times b\times d.$$

$$=\left(\frac{a}{b}\times b\right)\times\left(\frac{c}{d}\times d\right)$$

since the factors of a product may be taken in any order [Art. 22].

But $\frac{a}{b} \times b = a$, and $\frac{c}{d} \times d = c$ [Art. 79].

Therefore

$$xbd = ac;$$

or, x is the quantity which gives ac when multiplied by bd. But from the definition of a fraction $\frac{ac}{bd}$ is that quantity. Hence,

$$x = \frac{ac}{bd};$$

or $$\frac{a}{b} \times \frac{c}{d} = \frac{ac}{bd}.$$

Therefore, *the product of two fractions is a fraction whose numerator is the product of the numerators of the fractions and whose denominator is the product of their denominators.*

The product of any number of fractions is formed in the same way. Thus

$$\frac{a}{b} \times \frac{c}{d} \times \frac{e}{f} = \frac{ace}{bdf}$$

Answers to Algebra

Examples 18

1. $(x^2+2x)^2 - 11(x^2+2x) + 24$
$= (x^2+2x-3)(x^2+2x-8)$
$= (x-1)(x+3)(x-2)(x+4)$.

2. $(x+1)(x+2)(x+3)(x+4) - 48$
$= (x^2+5x+4)(x^2+5x+6) - 48$
$= (x^2+5x)^2 + 10(x^2+5x) - 24$
$= (x^2+5x-2)(x^2+5x+12)$.

3. $(x+2)(x+4)(x+5)(x+7) + 8$
$= (x^2+9x+14)(x^2+9x+20) + 8$
$= (x^2+9x)^2 + 34(x^2+9x) + 288$
$= (x^2+9x+18)(x^2+9x+16)$
$= (x+3)(x+6)(x^2+9x+16)$.

4. $x^3(y-z) + y^3(z-x) + z^3(x-y)$
$= x^3(y-z) - x(y^3-z^3) + yz(y^2-z^2)$, arranging in powers of x
$= (y-z)\{x^3 - x(y^2+z^2+yz) + yz(y+z)\}$, taking out the factor $(y-z)$
$= (y-z)\{y^2(z-x) + yz(z-x) - x(z^2-x^2)\}$, arranging in powers of y
$= (y-z)(z-x)\{y^2 + yz - x(z+x)\}$
$= (y-z)(z-x)\{-z(x-y) - (x^2-y^2)\}$, arranging in powers of z
$= (y-z)(z-x)(x-y)(-z-x-y)$
$= -(y-z)(z-x)(x-y)(x+y+z)$.

5. $(b-c)^3 + (c-a)^3 + (a-b)^3$. The factors of this expression are easily obtained from the following. We know that $x^3+y^3+z^3-3xyz = (x+y+z)(x^2+y^2+z^2-yz-zx-xy)$. Now, if $x+y+z=0$, the product on the right of this identity must evidently be 0, *i.e*, we have $x^3+y^3+z^3-3xyz=0$. Therefore $x^3+y^3+z^3 = 3xyz$. This result, expressed in words, is: *When the sum of three quantities is zero, the sum of their cubes is equal to three times their product.* In the given example we have three quantities, $b-c$, $c-a$, and $a-b$. The sum of these three is plainly zero. Hence it follows that the sum of their cubes is three times their product, *i.e.*, $(b-c)^3 + (c-a)^3 + (a-b)^3 = 3(b-c)(c-a)(a-b)$.

6. x^3+3x^2-6x-8
$= (x^3-8) + (3x^2-6x)$
$= (x-2)(x^2+2x+4) + 3x(x-2)$
$= (x-2)(x^2+2x+4+3x)$
$= (x-2)(x^2+5x+4)$
$= (x+1)(x-2)(x+4)$.

7. x^4+4x+3. If we put $x=-1$ we get $1-4+3$, which equals 0. Hence $x-(-1)$, or $x+1$, is a factor. Thus $x^4+4x+3 = x^3(x+1) - x^2(x+1) + x(x+1) + 3(x+1) = (x+1)(x^3-x^2+x+3)$. Again, putting $x=-1$ in the second factor, we see that $x+1$ is still a factor; the expression being $(x+1)\{x^2(x+1) - 2x(x+1) + 3(x+1)\}$ or $(x+1)^2(x^2-2x+3)$.

8. $yz(y-z) + zx(z-x) + xy(x-y)$
$= x^2(y-z) - x(y^2-z^2) + yz(y-z)$, arranging in powers of x
$= (y-z)\{x^2 - x(y+z) + yz\}$
$= (y-z)(x-y)(x-z)$.

Examples 19

1. abc^2.	5. $x+4y$.
2. $2x^2yz$.	6. $2a-1$.
3. $7x^3y^3$.	7. $2a+3b$.
4. $x-6$.	8. $2x^2(x-2y)(3x+y)$.

9. $3x(2x-y)$.

Examples 20

1. x^2-3x+5.	5. $2x-3$.
2. $2x-1$.	6. $2x^2-x+1$.
3. $a+b$.	7. $2x^2-4x-1$.
4. $a-1$.	8. x^2-5x+1.

Examples 21

1. $90a^2b^2c^3$. 2. $(a+b)(a-b)^2$.
3. x^6-y^6. 4. $36(x^2-1)(x^2-4)(x^2-9)$.
5. $(2x+3)(2x-5)(3x+4)$.
6. $(2x+3)(2x-3)^2(3x-2)$.
7. $(x-y)(x-2y)(x-3y)$.
8. $2xy^2(x-2y)(x+2y)(x-3y)$.
9. $4a^3b^2(a^2-b^2)$.
10. $12(x-1)(2x-1)(x^2-4)$.

Examples 22

1. $(x^2-2x+3)(4x^3-4x^2-41x+21)$.

2. Use factors, found by the Remainder Theorem. The L.C.M. is $(a-1)(a-2)(a-3)(a-4)(a-5)$.

3. Use factors. L.C.M. is $(x-1)(2x-1)(3x-2)(4x-3)$.

4. Use factors. L.C.M. is $(x^2-y)^2(2x-y)$.

Continued

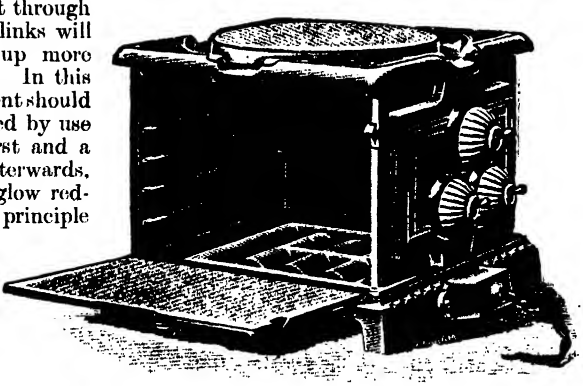
ELECTRIC HEATING

Laws of Electric Heating. Electric Radiators. Electric Cooking. Electric Furnaces for Metallurgical Work

By Professor SILVANUS P. THOMPSON

As has been pointed out in the course of these articles, whenever an electric current is forced through an imperfect conductor—that is, through a conductor which offers a resistance to the flow of electricity—the energy expended on forcing the current through the conductor is transmitted into heat. The conductor, in fact, is warmed or heated by the current that passes through it, the energy of the current being more or less frittered away, as by a sort of internal friction, according to the resistance of the conductor.

Simple Experiments on Electric Heating. Every glow lamp gives an example of the heating of a conductor (the filament inside the lamp-bulb) by the passage of a current through it. Whenever any wire is too thin to carry properly the current that is transmitted through it, that wire becomes hot, even red-hot if the current be strong enough, or it may even be melted. If water slightly acidulated be placed in a U-tube and a current sent through it by means of a metallic rod inserted in the limbs of the tube, and joined to a battery or to a dynamo, the water is rapidly heated. The greater the resistance of any conductor through which a given current is sent, the greater is the heating. Thin wires resist more than thick wires of the same material. If, therefore, a chain is made in which the alternate links consist of thin copper wire and thick copper wire, and a current is sent through the chain, the thin links will be found to heat up more than the thick ones. In this experiment the current should be gradually increased by use of a few cells at first and a larger number afterwards, until the thin links glow red-hot, illustrating the principle of the greater resistance of the worse conductor. Another variety of this experiment is to make a chain of pieces of equal thickness of copper wire and iron wire. As iron resists (for an equal thickness and length) about six times as much as copper, the iron links will be found to heat up red-hot as the current is increased, while the copper links remain cool.



206. ELECTRIC COOKER (General Electric Co.)

Laws of Electric Heating. The evolution of heat in an electric resistance is governed by certain definite laws. They are different according to whether we are dealing with a case in which the energy is supplied at a constant voltage or with one in which there is a given number of amperes of current.

At a Given Voltage. The heat developed per second in a resistance *varies inversely as the resistance.* As heat is a form of energy, the rate at which heat is developed can be expressed in watts [see page 291]. The rule is that the number of watts produced in heating a resistance is proportional to the square of the voltage of the supply, and inversely proportional to the resistance of the conductor that is heated. Suppose, for example, that we have a conductor (of wire or carbon) the resistance of which is 40 ohms, and it is supplied with current at a voltage of 100 volts, then the heat energy will be radiated from it with a constant value of $100 \times 100 \div 40 = 250$ watts. The current through the conductor will, of course, be $100 \div 40 = 2{\cdot}5$ amperes. If we were to substitute a conductor of double the resistance, the amount of heat-radiation would be reduced to one half, or 125 watts. But if the electric energy were supplied at double the pressure, the heat-radiation in the 40-ohm conductor would be increased fourfold, for then we should have $200 \times 200 \div 40 = 1{,}000$ watts. In fact, the rule may be put into symbols as:

$$W = V^2 \div R \qquad (1)$$

where W is the number of watts that are being developed, V the voltage of supply, and R the number of ohms of resistance of the conductor.

Another way of calculating the number of watts thus given out in heating is to calculate the current in amperes by Ohm's law [page 670] and then to multiply this by the voltage, since

$$W = C \times V \quad (2)$$

Yet another way is to calculate the current, square the number of amperes so found, and then multiply the resistance. Thus, in the above case, where a current of 2·5 amperes was sent through a resistance of 40 ohms, we may calculate as follows:

$$2{\cdot}5 \times 2{\cdot}5 \times 40 = 250 \text{ watts.}$$

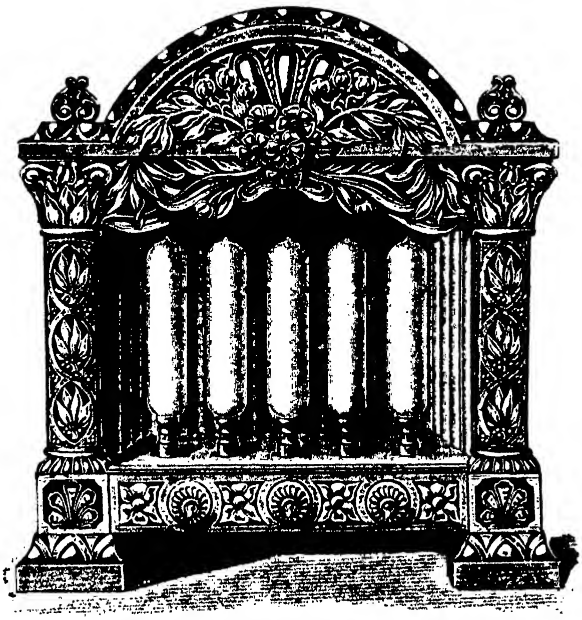
In this case the formula becomes:

$$W = C^2 \times R. \qquad (3)$$

In this last form the rule is known as Joule's law, in honour of Dr. Joule, who discovered

that the heating effect in a given resistance is proportional to the square of the current. But it is less useful in present calculations than the first rule, because the current is not a fixed quantity but depends on the resistance used.

Electric Radiators. The domestic heating radiators are now manufactured in many forms. One familiar form [207] consists of a number of special large glow lamps arranged to glow at a dull-red heat. These radiator lamps take about one ampere each; so a radiator with five such lamps, if supplied at 100 volts, will consume power at the rate of 500 watts. Such a radiator would suffice to keep a small room gently warmed. As 1,000 watt-hours (or one kilowatt hour) make one Board of Trade unit, such a radiator would consume half a unit per hour. Most supply companies charge—for heating purposes—the low rate of 1½d. or 2d. per unit. So that such a radiator would cost ¾d. to 1d. per hour while in use. Other radiators are made with conducting wires of considerable resistance embedded in enamel. A recent form employs a special powder of granulated carborundum mixed with graphite, enclosed in tubes or long cartridges, under the name of *Kryptol*, as a means of electric heating, the cartridges being enclosed in convenient stoves or radiators.



207. ELECTRIC GLOW RADIATOR (General Electric Co.)

Electric Cooking. For cooking, boiling, and heating curling tongs, laundry flat-irons, and the like, resistance wires of some suitable metal, such as German silver, are embedded in an insulating cement or enamel, so that when heated by the current a hot surface is produced. To heat a pint of water to boiling, the energy needed is about $\frac{1}{12}$ of a kilowatt-hour. Or, if energy be supplied at 1 kilowatt, the pint of water will be brought to the boil in about five minutes. The advantage of such methods is the absence of smoke and fumes, the entire cleanliness, and the circumstance that the heating is produced only when and where it is wanted. Fig. **206** illustrates a small oven for breakfast cooking, combined with a hot-plate for heating a kettle.

Electric Welding. If the ends of two iron rods or wires are pressed together, and an electric current is sent through them, the joint being an imperfect conductor, offers resistance, and is heated red-hot. If, when so heated, the parts are pressed together, welding takes place, and a remarkably perfect union is effected. Electric welding is now used for many different kinds of metal.

The Electric Furnace. A most important industrial application of the principles set forth at the beginning of the article is found in the *electric furnace*, by means of which a temperature much higher than that of the ordinary coke or charcoal furnace may be obtained. The applications of the electric furnace are twofold—namely, (1) in processes which of necessity require a temperature higher than that which can be obtained with the ordinary furnace (which is about 2,000° C.); and (2) in others which are workable also at lower temperatures, but in which the electric furnace is so compact that the cost of production is much less, and there are no products of combustion to carry away the heat.

The furnaces themselves may also be divided into two classes—namely, those in which the heating is done by the aid of resistance, as in the domestic heaters already described, and those in which an electric arc is formed, and is allowed to play on the contents of the furnace. Many types of furnace cannot, however, be classed definitely under these headings, as practice has shown the advisability of combining both actions in one form.

Moissan's Arc Furnace. The simplest form of arc furnace is that devised by Moissan, in France. As shown in **208**, the furnace consists of two blocks of chalk carefully dried and carved out so as to form a cavity in which a carbon crucible can be placed. Massive carbon rods pass into this cavity from opposite ends of the furnace, and the arc formed between them plays over the crucible, heating the material under treatment in the manner of the common reverberatory furnaces. Moissan has been able readily to melt even the most infusible of metals such as platinum and iridium, and has shown that gold is not only melted but boils, giving off a purple vapour. The use of this furnace is preferred in the production of metals, alloys, etc., which are themselves too conductive to be used in a resistance furnace.

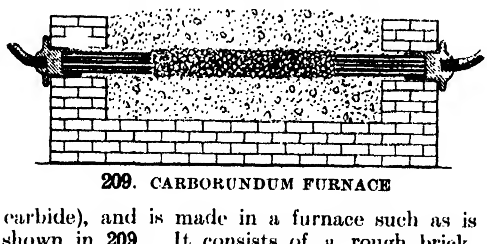
Resistance Furnaces. In these the resistance may consist either of specially provided conductors such as carbon rods, or of iron bars laid in grooves in the bed of the furnace, or of the

materials themselves, as in many processes these are semi-conducting, consisting of refractory ores mixed with carbon. In all true furnaces the heat itself brings about the reactions, but in one kind of apparatus depending on principles more particularly described in another chapter, the reaction is an electrolytic one, but as this action will take place only while the materials are in a fused state, the dimensions of the apparatus are so arranged that the materials are heated by the passage of the current.

Electric Furnace Processes. To give an idea of the practical application of the electric furnace, the following processes are briefly described:

1. Calcium Carbide. Lime and carbon are mixed together and heated to a high temperature by the passage of the current. Two forms of furnace are in use, one in which the process is continuous and the other in which it is intermittent. In the former the materials are fed down a funnel on to a hearth, where they are converted into the carbide, this being drawn off in the liquid state as it is formed. As calcium carbide solidifies at a high temperature, difficulty is experienced in devising arrangements for drawing off the carbide, so that a more usual way of manufacture is to feed the materials slowly into a bin with metal sides, and as the carbide is formed to raise the electrode so that in the end a solid block of carbide is withdrawn from the furnace and a fresh charge introduced. The carbide obtained in this way is liable to contain portions of uncombined lime, and so forms the cheaper qualities on the market.

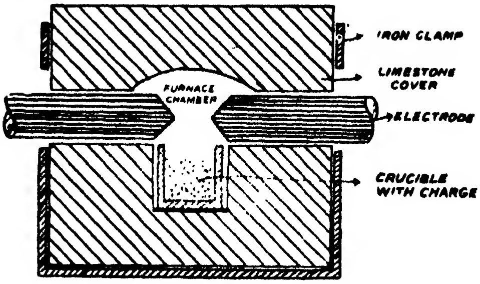
2. Carborundum. This is a compound of carbon and silicon (known chemically as silicon



209. CARBORUNDUM FURNACE

carbide), and is made in a furnace such as is shown in 209. It consists of a rough brickwork structure, which can be taken down and reconstructed for each run, and is designed merely to keep the raw material together. Each electrode is formed of a bundle of carbon rods set in a metal holder to which the leads are attached. Between the ends of the electrodes there is built up a core of broken coke, around which the core, consisting chiefly of coke and sand, is packed. A furnace measuring about 15 ft. by 7 ft. by 7 ft. requires about 1,000 horse-power when fully running, and takes about 36 hours, giving a yield of about 2 tons of carborundum.

3. Phosphorus. Improvements were devised, in 1888, by Readman and Parker for the electrical heating of the ingredients (phosphoric acid and carbon) which are used to make phosphorus. The old way had been to place small retorts containing the mixture in an ordinary furnace; but by introducing the electrodes into the crucibles and heating the contents partly by arc and partly by resistance methods, a much cheaper and purer product resulted.



208. MOISSAN'S ARC FURNACE

4. Nitric Acid. Nitrates are now being made in Norway by Birkeland and Eyde by passing a high-voltage alternating current discharge through air, the high temperature causing some of the atmospheric nitrogen to combine with oxygen, producing nitrous fumes which are absorbed in water, making nitric acid, or in lime to make nitrate of lime, which is a valuable fertilising agent. In the special furnace employed, the alternating arc is formed between the poles of a magnet, which causes it to take the form of a roaring disc of flame through which the air is passed.

Power for Electric Furnace Work. Electric furnaces cannot be used industrially unless the electric power is furnished very cheaply. Hence it is that factories for the production of calcium carbide, corundum, and nitrates are to be found only in the neighbourhood of the great natural sources of power—namely, waterfalls. Water-driven turbines drive suitable generators, from which the energy is conveyed as electric currents to the furnaces. Except for certain special electrolytic processes, such as the production of aluminium, in which necessarily the continuous current must be used, the currents supplied to electric furnaces are of the alternating kind. The reasons for this preference are briefly that the generating machinery is cheaper because of the absence of commutators, and that, because alternating currents can be readily transformed from one voltage to another, the transmission of the currents at high voltage through relatively thin conductors to transformers right at the furnace cheapens the cost of the installation.

It must be borne in mind that, in all electric furnace processes, success depends so greatly upon the sound engineering of mechanical details, and upon the good commercial organisation of the factories, that electrical details are of relatively minor importance. Most electric furnaces to be worked profitably must be kept going day and night without stoppage, since the load-factor (page 2816) must be kept as high as possible if the cost of the supply is to be low.

Continued

MASONRY PRACTICE

Forms of Walling. Bonding. Methods of Jointing Stones. Dowels and Cramps. The Dressing of Moulded and Enriched Work

Continued from page 2844

By Professor R. ELSEY SMITH

Walls—Setting Out—Footings. Walls may be constructed entirely of masonry, they may be formed principally of masonry and faced internally with brick to receive a plastered face, or they may be built largely of brick, with an external facing of masonry. The setting out of the position of masonry walls on the site may be carried out in the same manner as described for brick walls.

All forms of stone walls require to have footings below the base of the wall [**134**], and if these are made equal in projection and height to the requirements described for brick footings, this will be ample, and footings of somewhat reduced dimensions will, in many cases, suffice. They are constructed with fewer and larger offsets, owing to the nature of the material of which they are formed, and in the case of a rubble wall of about 2 ft. in thickness, there would not be, as a rule, more than two offsets in the footings, and in some cases only one.

Concrete under Walls. It is also desirable in many situations that such a wall should stand on a concrete bed as described for brick walls, but much will depend on the nature of the soil on which the wall is to stand.

Stone walls, especially all kinds of rubble wall, must, as a rule, be very much thicker than would be required for brick walls in the same building, owing to the nature of their construction. Rubble walls cannot be well constructed of a less thickness than about 1 ft. 8 in., and are more often about 2 ft. thick ; if provided with footings, the weight is distributed over a wide area, and concrete may often be omitted if the bearing quality of the soil be satisfactory.

In the case of most ashlar walls, the ashlar is, in fact, an outer facing to a brick wall, and the footings are formed of brick in accordance with the usual practice in brickwork.

Bonding. In all forms of masonry, the question of bonding the work thoroughly together —and, if it be not homogeneous, but composed of two different materials, of bonding efficiently the two parts together—is a matter of great importance. The conditions, however, are quite different from those of a brick wall in which all the blocks used, unless they are cut, are of uniform size, and small ; in a masonry wall, on the other hand, the individual blocks are, as a rule, considerably larger than bricks, and they vary very much in size, and often in shape, except in the case of ashlar, where the blocks are always large and truly rectangular. The bonding of masonry, therefore, is not reduced to certain definite and regular methods, as in the case of brickwork, but the mason must, to a large extent, use his judgment in selecting and distributing the blocks of which a wall is built, so that every course shall bond with the adjoining courses, not merely on the face, but through the thickness of the wall. The danger that was referred to in brickwork of a straight joint between two successive courses extending throughout the whole height of a wall, does not exist in masonry, from this very fact that we are no longer dealing with blocks of absolutely uniform size. Where a wall is being built of small stones, it is desirable that at frequent intervals some large stones should be laid in the wall with their longest dimension perpendicular to the face of the wall, as a header in brickwork ; these are termed *bond stones* or *through stones*, and some of them, if possible, should extend from the outer to the inner faces of the wall, unless the stone be porous in character and liable to convey moisture through the wall. The method of using these differs a little in different classes of work, and will be referred to as these are dealt with.

Building Angles. In the case of walls formed of small stones, it is convenient that wherever angles have to be formed, including ordinary salient and entering angles, and the salient angles of all forms of openings, that larger stones should be used, which can be more easily set and plumbed, and form a stronger angle than could be constructed with rougher stones of irregular size. These angle stones, which are termed *quoins*, bond with the work on both faces of the wall ; they are of special utility in constructing the walls, as they can easily be set out with a plummet, as in the case of a brick wall, the intermediate parts of the wall being aligned by means of a cord. To assist this setting out, the salient angle of such a block has usually a draft on each face if the remainder of the exposed faces are left rough. In building stone walls, if the beds are even and the mortar joints therefore are thin, the surfaces of the stone above and below the bed must be well wetted, or they will absorb all the moisture from the mortar. Even when the beds are irregular and the mortar joints thick, the stones should be wetted if they are dry and porous.

Method of Building Walls. Masonry walls are usually thicker than brick walls of the same height and length, and, as in the case of brickwork, the facing is first set out, and the *core* or *hearting*—that is to say, the centre part of the wall—is afterwards filled in. This requires considerable care. In the irregular classes of masonry, the backs of the facing blocks are left somewhat rough, and the stones used for filling in are not more than very roughly shaped, so that considerable interstices may occur ; these should be filled with smaller stones or *spalls*,

which are fragments knocked off the larger stones, and are set with mortar; but in this process, any tendency to drive in wedge-shaped stones, which will force out the facing blocks, must be avoided.

Different Classes of Walling. Masonry walling is described under the three general classes of *ashlar*, *block in course*, and *rubble*. Each of these is best adapted to certain classes of stone and descriptions of work. Rubble is the one that is used with the poorest class of material, though perfectly sound and very effective walls may be constructed in this manner.

Rubble. *Rubble* includes masonry of very different classes under this one general term, but it is applied to those forms of walling in which the sizes of the stones vary very much, but where the majority of the stones are small, and it is usual, in describing this class of work, to qualify the general term by some other descriptive title. But in all forms of rubble walling the beds of the stones are only roughly prepared by knocking off protuberances, and the mortar joints are, in consequence, thick. The face of the stones forming the wall may be dressed with a hammer, which is usual with such intractable stones as Kentish rag, or with a punch or chisel. Some forms of laminated stones, which are found on quarrying to be in small pieces, may often be employed with little preparation.

Common, Random, or Uncoursed Rubble. *Common, random,* or *uncoursed* rubble denotes work in which the stones are of irregular shapes without regular horizontal or vertical beds, though some of the beds are usually approximately vertical or horizontal [**135**]. A variation of this is known as *polygonal rubble*—a term applied to work of which the blocks are very irregular in form, but at the same time carefully prepared with a hammer, so that they fit well together without the use of spalls. It is often employed for Kentish rag, and permits of stones being roughly shaped when required, as, for example, in the voussoirs of a discharging arch, and quoins may be worked in of the same material with drafted angles. Bond stones in such walling consist of stones somewhat irregular in form built in with their long dimension perpendicular to the wall face.

Irregular Coursed Rubble. This variety, also called *snecked* or *squared* rubble, is employed with those classes of stone that are found to have well marked horizontal beds, but occur in beds of irregular thickness, and produce blocks of irregular size. The ends are usually made approximately vertical, but this is not universal; in this form of rubble the beds are horizontal, and are usually arranged to run through the length of several stones, but they are not made continuous for more than a few feet, and may be broken at any point to fit in a stone of greater depth. The process of *snecking* is the careful preparation and filling in of small stones to complete the shallow course, and bring up beds to a level. Bond stones are usually equal in height to two or three of the smaller courses.

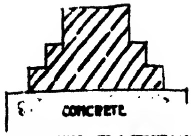
Rubble *built up to courses* [**136**] consists of rubble such as has already been described, but laid so that at irregular intervals of about 12 to 18 in. a true horizontal bed is formed, extending through the length and thickness of the wall. Any quoins or dressings are set out so as to correspond in height with these courses, and where the walling is of the same character as in irregular coursed rubble, and the bonding blocks in each course are equal to the full height of the course in which they occur, the work is described sometimes as *coursed header work* [**137**], and the headers in such a wall should equal about one-fourth of its total superficial area.

Regular Coursed Rubble. Regular coursed rubble is used where a more uniform appearance is required [**138**], and where stones are found fairly uniform in size, so that they may be sorted out to form regular courses, each course being formed of stones of the same height but of various lengths, and successive courses are not necessarily of the same depth.

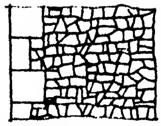
Flint Walls. *Flint walls* are a variety of rubble work much employed in districts where flints abound. The wall may be built throughout of flints, or they may be used merely as a facing, with a backing of brick or other stones. Flints are sometimes used just as they are found, unbroken; but when so employed produce a wall face that is rough in character; in many districts they are *knapped* or *polled*—that is to say, the stone is split so as to show a vertical face, when the dark colour and smooth texture of the flint make a very beautiful wall surface, especially when combined, as is usual, with dressings of stone or of red brick. In the finest work the stones are not only split, but roughly squared, or cut to other forms, and they may then be used to form panels let in flush into stonework. Much effective work of this kind is to be seen in the eastern counties of England.

Dressings to Flint Walls. Flint is not a material that is suitable for forming quoins or dressings, and where stone is available quoins and dressings are formed of this material. At salient angles the quoins are formed in the usual way, showing on both the front and return face of the wall, and so also in the case of dressings to openings. At internal angles, where two walls meet, or where a buttress projects from the wall face, the ashlar blocks are made long, and show alternately on the face of the two walls, part of the stone being concealed behind the other wall, which is stopped against it, and in this way a very strong angle is formed, and one that is also effective [**140**]. This may be done equally well where the angle formed is not a right angle, as, for example, where an angle buttress is formed at the external angle of a building, the sides of the buttress forming in each case an internal angle of 135 degrees with one face of the wall.

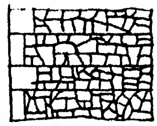
Except in the case of quite low walls, it is often usual to introduce horizontal stone courses at regular intervals of about 6 ft. or less, which are termed *lacing courses*, and act as bonding courses. A very beautiful effect is produced by building flint walls as coursed header work, arranged so that the headers are perfectly square,



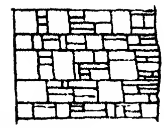
134. FOOTINGS TO A STONE WALL



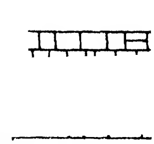
135. RANDOM RUBBLE



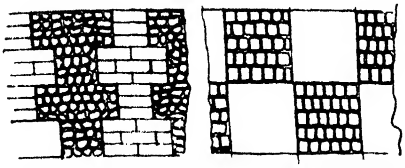
136. RUBBLE BUILT TO COURSES



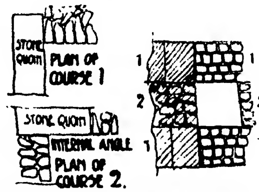
137. COURSED HEADER WORK



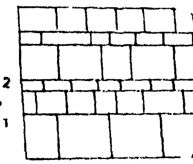
138. COURSED RUBBLE



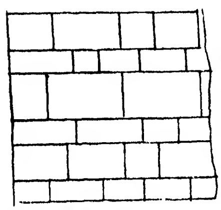
139. FLINTWORK WITH STONE OR BRICK DRESSINGS



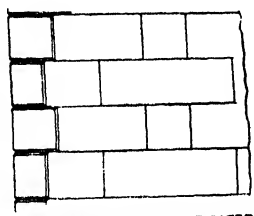
140. METHOD OF BONDING FLINT QUOINS



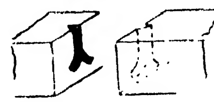
141. BLOCK-IN-COURSE



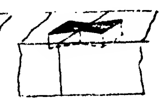
142. ASHLAR



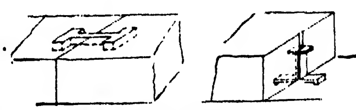
143. FINE ASHLAR WITH RUSTICATED QUOIN



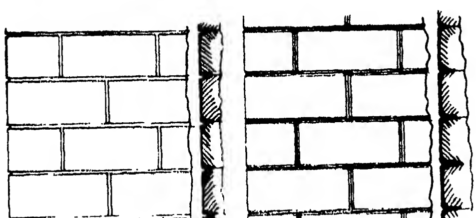
144. CEMENT JOGGLE



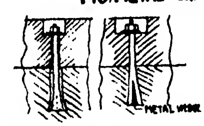
145. SLATE CRAMP



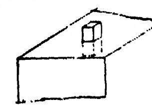
146. METAL CRAMPS



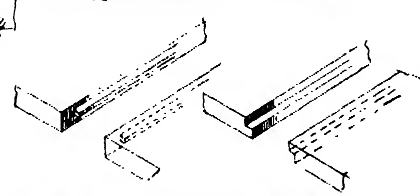
147. ASHLAR WITH SUNK & RUSTICATED JOINTS



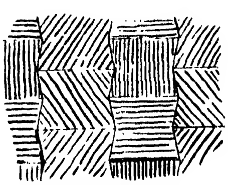
148. VERTICAL CRAMPS



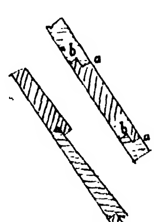
149. DOWEL



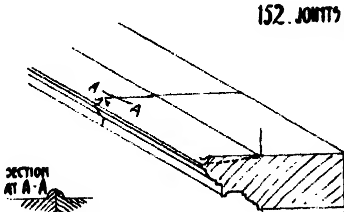
150. JOGGLE JOINTS & REBATES FOR LANDINGS.



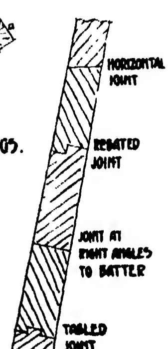
151 DOVETAILED WORK



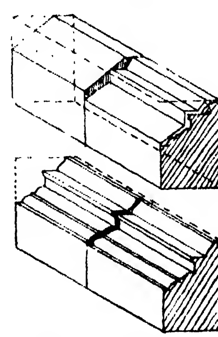
152. JOINTS FOR COPINGS.



153. SADDLE BACK JOINT



154. JOINTS USED IN BUILDING SPIRES.



155. METHOD OF WORKING MOULDINGS

EXAMPLES OF STONE WALLING AND VARIOUS METHODS OF DRESSING STONES

and equal in width to the spaces between them, and arranged in alternate courses like the squares on a chessboard [139]. A stone of a warm, rich yellow gives a good effect.

Brick Dressings. Brickwork may be used in a similar manner to stone, and red brick is usually selected; quoins, dressings, and lacing courses may be employed, and are effective in appearance, and produce a good sound wall.

Such quoins are usually formed of from two to four courses of brick, the smaller quoins showing 9 or 14 in. on the face, and the larger quoins an additional half-brick on face [139].

Where openings are formed in a flint wall, the head and sill in the case of a window, and the head and threshold in the case of a door must also be of brick or stone. A brick arch, flat or cambered, as already described, or a stone arch or lintol is used for the head, and where a sill is required it may be of either brick or stone, but a threshold is usually of stone. It is desirable whenever possible that the inner face of the wall should be lined with brick if it is to be plastered, or with ashlar if it is to be exposed.

Mortar Joints. The mortar joints of all kinds of rubble work are usually thick, and most of the joints described for brickwork may be used as a finish, but of these a flat or a weathered joint is most commonly used, and another form of joint known as a *mason's joint*, is employed, in which the lower edge protrudes slightly, forming a drip. Where the joints are very wide it is sometimes the custom after the joint is formed, and before it is set, to stick into it chips of flint or stone or fine pebbles, at short intervals, forming a line near the centre of the joint, and reducing its apparent size somewhat. This process is known as *galleting*.

Dry Rubble. Dry rubble is sometimes employed in stone districts, but mainly for fence walls; if well constructed, it makes a fairly solid wall, which, unless deliberately overthrown, will last for a long period; such walls are usually formed somewhat tapering in section, with an average thickness of about 18 in., and may be constructed 5 or 6 ft. in height. The top should be protected by some form of coping, and the best manner of forming this is to use blocks of the width of the top of the wall, the tops roughly rounded in form, and, if this coping be set in good mortar, it adds materially to the strength and life of the wall. Failing this, sods of turf will do a good deal to keep wet from the heart of the wall.

Block-in-course. The term *block-in-course* is given to walling which does not differ essentially from coursed rubble, for in this case also every course is formed of stones of equal height throughout the course but of various length, and the successive courses are not of uniform depth, varying from 3 in. to about 10 or 12 in. in height [141]; but this term is applied to walls formed of a better quality of stones, which are usually carefully squared and formed with fairly fine ends. The face also is usually hammer dressed. As a rule the average size of the courses is deeper than those in coursed rubble work. This class of walling is much used for the facing of large piers and by engineers in stone districts. The joints are usually somewhat finer than in rubble work.

Ashlar. Ashlar is the finest class of masonry, in which the blocks are all carefully squared and prepared with fine bed and heading joints. In the finest ashlar the courses are uniform in height throughout, and the stones are also worked to regular and uniform lengths, and are arranged so that the alternate courses bond [143]. This may be done by using stones of two widths on the face, corresponding with the header and stretcher in brickwork, and set out on the principle of Flemish bond, or it may be formed with blocks of uniform size by employing quoins of different lengths in alternate courses. Ashlar is not always so regular as this; both the courses and the individual stones may vary in size, but they are always truly squared and dressed with fine joints [142]. The face of the stone may be finished in any of the methods described in the previous article, and it is not unusual when a plain ashlar face is adopted for the general surface to employ rusticated or vermiculated quoins. In forming ashlar walls it is customary with certain styles of architecture, in order to give greater variety to the appearance of large surfaces and an effect of boldness, to mark the outline of every stone by a sinking [161 and 162]. This emphasises the construction and gives scale to the building. It is in no way a structural necessity, but is purely an appropriate enrichment, as is much else in good masonry.

The simplest form of sinking is formed by a shallow rebate worked round the edge of each stone [147]. In forming this it should be arranged wherever possible that the joints should occur at the top of the rebate, and not at the bottom, as one thus formed is much less likely to allow water to penetrate at the joint. Another simple form consists of a V-joint [147], a chamfer being worked all round the edge of each stone, and in this case the joints between adjacent stones are formed at the point of the V. The surface of the joint may be rubbed or tooled as desired.

These are the forms usually employed in plain ashlar; but, where rusticated or vermiculated surfaces are given to the stones, increased prominence is given to them by the use of a small group of mouldings running round the panel [see B., page 2841]. These joints are not confined to the rectangular blocks of plain walling, but may be used equally to emphasise the large blocks, or voussoirs forming an arch, and in large structures often fulfil an important function in the design [133].

Constructing Ashlar Walling. The courses in ashlar work are usually at least 12 in. in depth, and are often very much deeper; the mortar bed should not exceed $\frac{1}{8}$ in., which implies a very true and even upper and lower bed to each course. In laying the stones they are first fitted in position dry, and when found to be true they are lifted, the surfaces of the two stones below and above the joint are sprinkled with water, the mortar bed—composed of one part of hydraulic lime and two parts of fine clean sand—

is spread on the lower stone, made as level and even as possible, and the upper stone is then lowered to its place ; it is afterwards tested with a spirit-level, and if not perfectly true, may be slightly shifted with the help of a wooden mallet. If it cannot be levelled by this means it must be raised, and the mortar bed adjusted, where required, so as to raise or lower part of the bed ; but great care is required to see that the mortar is spread truly and evenly, otherwise even with carefully-prepared beds there may be an inequality of bearing in different parts of the stone and a consequent tendency to fracture.

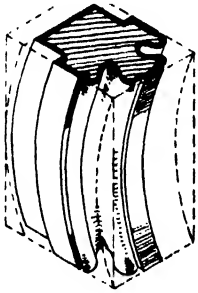
Backings to Ashlar Walls. In most work the ashlar does not form the full thickness of the wall, but is used as a facing, and is backed up with brickwork [**68**, page 2177]. When this is the case the minimum thickness of the ashlar face should be fixed, and this should never be less than 4 in. ; it should be arranged so that about one-third of the total area of the face is built into the backing for at least an additional half brick. The stonework is usually bedded in lime mortar, as cement will stain the face of the stone, but the brick backing should be formed in cement mortar, or there will be a tendency, with the many brick joints, for a greater settlement to occur in the brick backing than in the ashlar face. The cement used in the backing tends, if the ashlar be thin, to work through to the face and stain it. To guard against this the backs of the stones may be protected with a coating of slurry formed of stone dust mixed with a little lime.

Forming Cement Joggles. It is usual to strengthen the heading joints by cutting a V-shaped sinking in the corresponding faces of two adjacent stones ; after they are bedded, the cavity thus formed is filled with liquid cement, which as it sets hardens and prevents any lateral movement [**144**]. Such a cement joggle is a source of strength, but is liable to stain the stone, and it is best suited to thick blocks, and a slate or a metal cramp is better employed if the stone has only a thin bed.

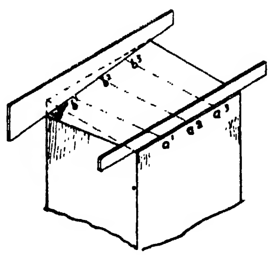
Slate Cramps. The slate cramp consists of a block of slate of uniform thickness, generally an inch or more, which is cut into the form of a double dovetail. A single dovetail mortise is cut in the upper surface of each of the two stones to be tied together. When the stones are placed side by side in position, these form a double dovetailed mortise, into which the prepared slate is fitted and set with mortar or cement, and binds the stones together [**145**].

Metal Cramps. These vary in form, but they generally consist of a bar of metal with an enlarged head or cross-piece at each end. Mortises are cut in the two stones to be united to receive the heads and chases for the body of the tie, so that it can be sunk below the upper surface of the stone, and when in position it is run with cement or lead [**146**].

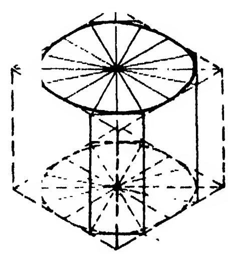
Such ties, if of iron, must be galvanised, as there is a danger that if moisture reaches them corrosion will take place, which, by increasing the bulk of the iron, may in time suffice to split the stone, or may at least discolour the surface. If the cramps are completely bedded in cement,



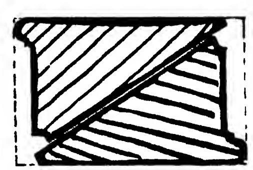
156 MOULDINGS IN CIRCULAR WORK



157. METHOD OF WORKING WINDING SURFACES.



158 METHOD OF WORKING CYLINDRICAL STONES.



160. TWO STEPS CUT FROM A BLOCK OF STONE.

this preserves the surface of the iron from rusting. There is often danger in using lead as a filling in any situation where moisture has access, for a galvanic action may be set up and the iron gradually eaten away. The result of such action may frequently be seen where iron railings have been let into a stone kerb and run with lead. In such old railings the section of the iron is greatly reduced immediately above the kerb, and sometimes almost entirely eaten away.

Copper, though expensive, is the best material for all such cramps, as also for dowels used in masonry, where metal dowels are required.

Where the object is not so much to give strength in a longitudinal direction as to prevent any lateral shifting, a different form of cramp is used, which may be let into the heading joint, not into the upper surface. A metal bar is used shaped rather like a short section of an ordinary rolled

161. SUNK JOINTS TO VOUSSOIRS, WATERLOO BRIDGE, LONDON

joist; this is first let into the heading of one stone and run with cement, and afterwards the next stone, which has had a cavity prepared for it, is placed against it [**146**].

Vertical Cramps. Occasionally it is necessary to unite two successive horizontal courses with a metal tie. One end may be enlarged, roughened, and let into the lower stone, and the upper end passes through a perforation in the course above and is tapped and fixed by means of a washer and nut. Another method of fixing the lower end without the use of either cement or lead is to form the lower part of the hole formed for the bolt in the form of a cone spreading towards the base. The rod has the lower end split by three or more cross cuts, and is fixed by inserting in the bottom of the hole a prepared metal cone, resting usually on the upper surface of the course below. The split end is inserted and driven down upon the cone, which separates and spreads the parts into which the rod has been cut and forces them against the side of the stone; when driven well home it is impossible to withdraw the rod. The upper end may be secured in a similar way by driving a cone in upon a split end or by tapping the end and using a nut and washer as before [**148**]. Such precautions are not required in ordinary building, but may be necessary in any marine work exposed to the action of waves.

Dowels. *Dowels* [**149**] are mainly used to prevent any lateral movement, as already described for terra-cotta, but in addition to being employed between successive stones, or courses of stones, they are used for steadying the feet of any solid frames and posts resting on a stone base; for example, the side posts of a door frame standing on a threshold of stone are dowelled to it, so also with a verandah or covered way the feet of the posts are dowelled to the stone kerb or basis in which they stand. The dowel may be of metal or slate, and is then let into the wood post and run with whitelead, or sometimes merely a long pebble is used, which should fit closely the mortice cut at the end of the post and in the stone, and which is sufficient to prevent any lateral movement.

Forming Special Joints in Stone. Besides employing other materials to strengthen the joints between successive courses of stones, there are various methods used for strengthening such joints in the process of dressing the stone itself. Nearly all these methods involve a considerable amount of labour and some waste of material, and they are reserved for positions in which such additional strength as they give is essential.

The most usual of these is *joggling*, which has already been described [see page 2783]. If a stone head be built up of a series of small stones resembling terra cotta blocks, the same system of jointing them may be employed, but, as a rule, it is possible in masonry to get stones long enough to span any openings of ordinary length which it is essential should have a lintol and not an arch over them. But joggling is very usually employed for landings [**150**], where comparatively thin stones of considerable area have to be jointed up, and in such cases the joggle is usually stopped some little way back from the face of the stone, and is formed as a slightly tapering projection fitting into a corresponding mortice or sinking in the next stone. A rebated joint is sometimes used for landings, and sometimes a sinking is formed in the heading of each stone, and a long slate dowel inserted. This is more easily cut, but is less efficient than a joggle.

Tabled Joints. For strengthening horizontal joints *tabling* is sometimes resorted to [**154**]. This consists in working a projection on the upper bed of one course of considerable area and providing a corresponding sinking in the succeeding course into which it fits. This forms a strong joint, but entails a good deal of labour and waste, and is required only where there is likely to be considerable lateral strain, either as the result of shock or thrust. Such a joint is used in marine

work, and in the lower course of spires, where horizontal joints are used; but for the latter a simple rebated joint may also be made use of. For very special work, as in the foundations of the Eddystone Lighthouse, the stones were very carefully framed together with dovetailed joggles [151] so as to withstand the shock of immense waves bursting against the base.

Jointing Copings and Weathered Surfaces. In jointing the copings of sloping gables a rebated joint should be used to prevent the penetration of wet to the wall, and care must be taken to see that the point *a* is lower than the point *b* [152], so that, in the event of the mortar perishing and water getting into the joint, it will pass out again and not get through the joint to the wall.

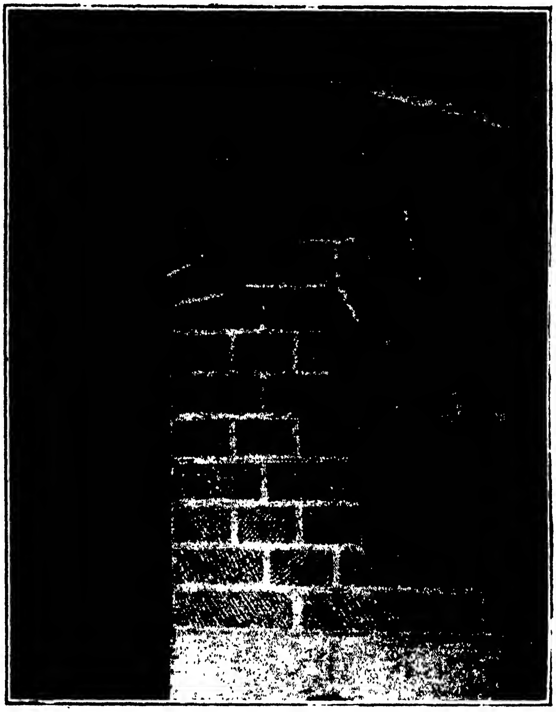
This form of joint is used when the upper surface is in one plane; but copings and water tables are often finished by using slabs not of uniform thickness, but tapered so that the lower edge, which is thick, is rebated over the thinner upper edge of the next block, and it may be provided with a small hollow moulding to serve as a drip.

For stones of which a large part of the upper surface is exposed to the action of the weather, as in the case of the large projecting stones of a cornice, there would be some danger that water would find its way into the joints of the upper surface which is *weathered*—that is, worked to a slope to throw any water falling upon it towards the edge. To protect such joints the weathering is not carried through the entire length of each stone, but at each end of it a narrow band or fillet of stone is left raised [153]. This may represent the original surface of the block, or it may itself be slightly weathered. The outer edge of the fillet corresponds with the heading joint; the inner edge is rounded off to meet the weathered surface, and this form of joint is termed a *saddle-back joint*.

Moulded and Enriched Work. We have dealt so far with perfectly plain work built to form various classes of walling; and we may note that every stone must be to a greater or less extent wrought or dressed before it is built in, whereas most bricks are employed just as delivered. With masonry, therefore, to a greater extent than with brickwork, there are facilities for varying the surfaces, and particularly the arrises of the blocks, by the employment of mouldings, which give an added interest and beauty to the lines surrounding an opening, or in the form of bands or courses of mouldings; the highest art of the mason is exhibited in the setting out and working of moulded and enriched work on wall surfaces, including arcades and niches, in openings with tracery enrichments, and in vaults and domes. Such work often requires an advanced knowledge of geometry to enable the mason to set out his work as well as high technical skill to execute it.

But however great the elaboration of the enrichment or the irregularity in the form of the block to be worked the mason must start from a simple block of stone and reduce it to a regular shape, on which he can set out his mouldings, and from which he can sink his irregular surfaces, and all stones, whether elaborate or simple, go through the same kind of processes.

Method of Sinking Mouldings. The method of squaring up a stone has been already described. Let us assume that we have such an oblong block of stone which is to form part of the cornice of a building, and consider the processes of reducing it to its ultimate form. The mason is supplied by the architect with a full size section of the moulding to be worked; this is first transferred from the drawing to a



162. RUSTICATED MASONRY, SOMERSET HOUSE, LONDON

sheet of zinc on which the outline or profile is marked with a sharp point and then cut out accurately, so as to produce a very thin section of the exact form of the block to be worked. This section is termed a *template*. If, now, our block has been accurately reduced to the thickness of the finished stone, the template may be applied first to one end of the stone, and its outline scribed on the stone with a sharp point; it is then applied to the other end, and again scribed [155]. There will generally be found to be certain well marked planes which approximately contain the lines of mouldings within them, and these are also marked in the ends of the stone. The two ends of every such plane are marked on the face or bed of

the stone, and are connected by a line scribed on the surface. The first process is to knock off the superfluous stone and reduce the block to a shape approximating to the finished form, and for this work the pitching tool is often used. From this face the mouldings, if they be close to it, may be sunk direct, or, if necessary, further general sinkings may be made, and in marking and forming these the bevel comes into service; for the main surfaces being no longer at right angle, the square cannot be used. In every case where the moulding runs throughout the length of the stone, each successive plane is worked off along the whole length before the final process begins. In working the mouldings they are first roughly chiselled to their approximate size and shape but about $\frac{1}{8}$th in. full, and they are finally cleaned up with narrow and rounded chisels; but the ends of such mouldings for an inch or two next the heading joint are often not cleaned up till after the stones are fixed, to facilitate any slight adjustment of the alignment that may be required. The straightedge is used to test the accuracy of the long lines frequently, and care must be taken in the early stages not to sink any part of the work below the level of the finished face.

Mouldings in Circular Work. In the case of mouldings worked on a curved surface, as, for example, in the case of a moulded vaulting rib or an arch stone, the process is similar, but the block, after being squared, is next reduced to the form of the required curve before the sinking of the mouldings is taken in hand [**156**], and in doing this a face-mould is employed to mark out the curved block.

Winding Surfaces. For some purposes it is necessary to give to the stone not a true but a winding face; to do this, in place of using two parallel-sided straight-edges only one such is used, while the other has diverging edges set out to give the amount of twist required. The distance apart of the rods must be accurately fixed. The parallel-sided straightedge is placed on the near edge of the block of stone on a draft prepared for it, the other being applied to the further edge, on which a draft is worked down till the upper surfaces are found to be level when boned. Straight drafts are then worked along the sides of the stone connecting the two ends of those first formed for this purpose, the two ends are subdivided into any convenient number of equal parts—a^1 a^2 a^3 and b^1 b^2 b^3, etc.; then straight drafts are worked across from a^1 to b^1, a^2 to b^2, etc., and the intervals between them may be again subdivided and worked off similarly [**157**]. Such a surface is required in the soffits of stairs and for skew arches.

Working Cylindrical Blocks. In working a plain cylinder, the block must first be squared, the circle scribed on each end, and a series of points on the circumference found. The two diagonals may be drawn, and where they cut the inscribed circle four points are secured, and any number of intermediate points may be found. The cylinder may first be reduced to an octagon by setting out an octagon enclosing the circle and working off the angles, and straight drafts are then chiselled down the side from end to end of the stone [**158**]. If the column is diminished—*i.e.*, if one end is to be smaller than the other—it will be necessary only to inscribe the two circles of the correct sizes; the diagonals, by their intersection, fix the centre or axis of the column at each end, and will divide each circle into four exact quadrants, and care must be taken to subdivide each of these into the same number of parts; in other respects the work is carried out as for a simple cylinder.

If the block is not only to be diminished but to have an *entasis*—that is, a slightly curved outline—it will be necessary, instead of using a straight edge for testing the working of these drafts, to have a profile cut to the exact curve required, which may be applied in the same way as a straight edge. In the case of all circular work, whether plain, as above described, or moulded, as in the case of balusters, the stones where machinery is available may be turned in a lathe.

Cutting Voussoirs. In cutting the blocks or voussoirs to form an arch it is not necessary to reduce every stone to a square block as the first process; but a long stone having first been squared, the shape of the blocks may be set out on the face and back by using the face-mould and reversing it for every alternate stone, and cutting out the blocks with a saw; sufficient room for the saw-cut must be left, and the sides of the voussoirs can be afterwards dressed with but little labour [**159**]. This method economises both stone and labour. So, also, two spandrel-shaped steps may be sawn out of a rectangular block of stone, provided they are of uniform section throughout and are not required to have a square seating for building into a stone wall.

Continued

GROCERS

We shall consider the business of a grocer who is also an Italian warehouseman. The Italian warehouseman, who at one time dealt in foreign fruits, lemons, oranges, olive oil, macaroni, and sardines, has become almost extinct as a separate tradesman, although here and there a department of this kind is carried on in conjunction with the trade of a general fruiterer. Practically, the trade is now merged in that of the grocer, who is also frequently a provision merchant, an oilman [see OIL AND COLOURMEN], and a wine and spirit merchant or bottled beer retailer under an off-licence; in fact, many modern grocers adopt the "sell-everything" principle which has proved so successful in the great stores. The theory is that customers who visit a shop to buy one article often buy others, and that it is wise, therefore, to leave them no excuse for seeking a rival trader's establishment.

How to Start. Many of the most successful grocery businesses have grown from very small beginnings. The grocery trade is one in which the personality and energy of the proprietor count for much, especially where the business is in its infancy. Also it goes without saying that the grocer beginning business should have a practical knowledge of his trade, although many a business has been started from the germ of a small general shop by persons whose only technical knowledge lay in acquaintance with a larger shop from which to buy "to sell again." Where such ventures succeed, it is usually because they possess the essential justification of existence in meeting the wants of a neighbourhood not better supplied. Villages, new suburbs, districts of all kinds, as a rule, grow, and shops grow with them. Many grocery shops have been started by young managers who have obtained a knowledge of a locality, and perhaps espied a growing corner when in the employ of old-established firms. But nowadays grocers when engaging assistants generally protect themselves against this by "restraint" agreements, under which the assistant binds himself not to start in business within so many miles of a given town until the expiration of a term of years after leaving the employer's service, under penalty of a named sum as liquidated damages.

Capital. Thus the question of starting becomes largely one of the capital at command. If the would-be grocer has money enough, he may often find advertisements in the trade papers of businesses to be bought as going concerns—in which case, goodwill, "the benefit arising from connection and reputation," may have to be purchased besides the fittings, stock, and book accounts. The services of a trade valuer should be requisitioned in buying a business, and the buyer should be on his guard against being saddled with old stock, while he should also take care that debts and running accounts are made over to him in proper legal form lest he should subsequently need to prove his title thereto. But if the beginner has no more capital than the £170 or £200 mentioned elsewhere as the indispensable minimum, he is hardly likely to purchase a business. What he will probably do, either alone or in conjunction with a reliable friend of similar views, is to spy out the land until the suitable "pitch" for a new shop is found, then seek out the suitable shop, having regard most carefully to the length of his purse. He has to provide for (1) fitting the shop; (2) stock and renewal of same as required; (3) rent, rates, wages (if any), and working expenses; (4) his own maintenance.

Selection of Premises. In selecting premises for a shop, the first consideration will be, as a rule, the position, in view of the class of trade expected to be done. As the beginner's purse is so limited, he can hardly expect to obtain one of the coveted corner sites that are so valuable in all growing neighbourhoods for trades where the window display counts; but he will at any rate look out for a shop that has a good window, or possibly two windows; that does not get too much sun, though not in the shade; that has not a front door likely to get all the dust of the street; that has a room at back, or over, suitable for a stock-room, also a dry cellar if it be the intention to keep provisions. Take care, further, that the drainage is satisfactory, and that there are no rats. The rent of a shop for a grocer beginning business on £200 or so of capital can hardly exceed £50, with safety, and probably £30 or £35 will be the better limit, though this depends largely on circumstances.

Fittings and Fixtures. A good facia is always necessary for a grocer, and "good" does not mean one of the cheap and gaudy kind. Each window should be of plate glass in one piece where possible. "Fixtures" in a shop are ordinarily those fastened to the ceiling, walls, doors, and floors, while "utensils in trade" are movables; and it may be noted that fixtures and fittings which a tenant puts up in a shop for the purposes of his trade remain his property, and can be taken away by him. Having decided what amount of his ready cash he can allot for fixtures, fittings, and utensils in trade, the shopkeeper will doubtless call in the services of one of the regular shopfitters to the trade. Unless second-hand counters and "fittings" can be obtained, and boxes utilised for ekeing out shelves and drawers, it will hardly be possible to expend less than £50 or £60 on fixtures and fittings, and very much

more might easily be spent. Mahogany or baywood is needed for the top of the grocery, and white deal for that of the provision counter. Glass signs, bacon-rails, sunblinds, butter-stands, tea-canisters, a small coffee-mill, a currant cleaner, scales and weights, a truck, step ladder, vinegar measures, syrup-can—in such ways the money goes. Gas-fittings should be very carefully placed to give the best possible light.

A Model Grocer's Shop. The view given of an interior [1] fitted by Messrs. Maund, of 344, Old Street, London, E.C., suggests what can be done.

A brief description, with prices of fittings such as are shown, will assist the beginner to estimate the cost and will teach him how far his purse will stretch. The principal fixture is the wall fitting, which should not be less than 16 ft. long, 9 ft. 6 in. high to the top of the cornice, and 18 in. deep at the bottom part. The lower part to a height of about 2 ft. should be provided with continuous ranges of open lockers about 2 ft. long and in two heights.

Above these in the shop shown are patent tea-bins with metal-lined receivers under which is an ingenious fitment whereby the tea stored in the bins—to the amount of 60 to 80 lb.—flows automatically into the receivers beneath. The latter have lids for easy access when serving. This ensures that the bulk of the tea is kept from the air, and another important point is that the dust is sold together with the tea instead of accumulating in the last few pounds removed.

The fronts of the bins are decorated in gold and colours, a useful medium for advertisement, and, being at the eye level, are always prominent. An alternative design has mirror panel doors in front of the bins, which are decorated on the back of the glass. Between the bins are nests of spice drawers with glass fronts, having about ½ in. space at the back of the glass in which samples of the goods in the drawers are shown. Along the tops of all is a shelf for tea canisters, and above this a shelf for seed-tins. These, of course, can be used for packed or other goods at pleasure. All the fitting is faced on front with polished mahogany to ensure long wear.

In the centre of the upper part of the fitting is a plate glass and mahogany case for scents, patent medicines, or delicate goods requiring care to prevent depreciation by dust and air. The whole fitting is mounted with an artistically moulded cornice faced with polished mahogany and birdseye maple.

The ornamental pediment over the case is to match . . cornice, and, if desired, an eight-day clock can be fitted in the centre. If the ceiling is not at least 15 in. above the top of the cornice, it is sometimes advisable to dispense with this pediment and to fit the cornice at the level of the ceiling.

The counter should be as long as the site permits, and should never be less than 24 in. wide or more than 2 ft. 11 in. high. The top of that in the model shop shown is of polished mahogany, 1 in. thick and thicknessed out on front and ends with a light moulding. The front should be framed of solid mahogany and panelled with veneered birdseye maple, the mouldings being of bolection or raised pattern.

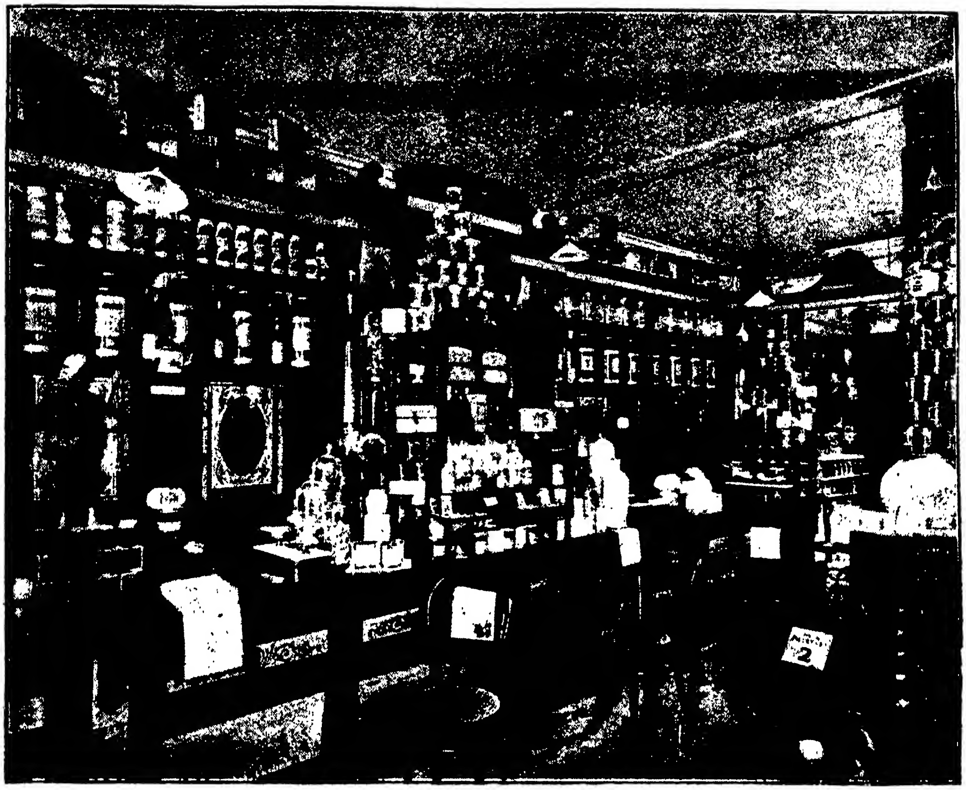
The fronts may be upright or slightly sloping. The interior of the counter should have two rows of drawers for fruit and sugar, the top row about 15 in. long and the bottom row about 23 in. long, with skirting underneath, which should be recessed about 2 in. so that it is not in the way of the assistants' toes. On the top of the drawers should be rows of spaces for wrapping paper. A neat addition to this counter is a few display shelves of glass, 15 in. by 18 in., mounted on brass pillars about 30 in. high rising from the back of a small bent-fronted glass case about 18 in. long and 8 in. high with a door at the back. If these are placed on the counter about 3 ft. apart, the spaces between suit as serving places for assistants.

The wall fitting described is worth, per foot run, 65s. to 68s., or, with canisters, 70s. to 73s. The counter costs per foot run, without show cases described, 20s. to 22s.

The price of tea canisters to hold 14 lb. each is 7s., or included in the cost of the fitting, would make the latter 70s. to 73s. per foot run.

Other Fittings and Appliances. The grocer beginning with £200 cannot afford first-class fittings, but he will usually find it better to avail himself of trained and expert advice than to trust to his own ingenuity and the skill of the local carpenter. A common practice is to divide the shop into two departments—a grocery side and a provision side, each with its own window and separate counter and fittings; while in the centre of the shop may be placed show frames for green fruit, lemons, bananas, oranges, tinned goods, etc., and at the rear end a special fitting for such things as brushes, etc. A coffee roaster is a useful and necessary piece of machinery. Tea mills and mixers are not needed unless the grocer blend his own teas—a practice which has been dropped by many. Proper tea-bins are needed, however, as tea deteriorates unless the air be excluded from it. Warehouse bins, with rounded bottoms, are now commonly made of galvanised steel. When the grocer possesses suitable machinery for the purpose, it is often found an attraction to roast and grind coffee in the window.

In the same way a bacon-slicing machine, which is capable of cutting remarkably thin slices, is often a great "draw." Window-dressing is itself something of a fine art, and one that is well recognised as influencing trade and gaining customers. Ingenuity and an eye for colour and general effect are the personal qualities necessary; the other factors are a suitable window (as to which the shopfitters are the best guides) and suitable stock. Smart-looking tickets, and not too many, should be used. A good plan is to make special displays of seasonable goods—*e.g.*, a window of house-cleaning materials and paraphernalia when the spring cleaning is at hand—and to change them frequently. Moving figures are often used, but though originality always counts, too much fondness for the stage properties and trumpery



1. THE INTERIOR OF AN UP-TO-DATE GROCER'S SHOP

models affected by some dressers is not advisable for the grocer.

Plan of Business and Stock. This will depend naturally on the needs of the neighbourhood for which the grocer intends to cater, and the extent of his means for so doing. If there be a wholesale house in his neighbourhood it will be an advantage, since provisions and other goods lose weight rapidly by evaporation when kept in a shop, and this loss in shrinkage may be minimised by keeping stocks as short as possible. Moreover, the fresher goods are, the better. It should be possible to buy provisions so that the capital invested in stock shall be turned over 52 times a year, and to buy groceries so that the capital shall be turned over eight times or more in a year. With regard to such staples as tea and coffee, it is necessary to take especial care to buy in the right quarter. Nowadays, comparatively few grocers in a small way buy "originals"—teas as originally packed at the tea gardens; nor do they carry out their own milling, mixing, and blending. They buy ready blended teas from a house on which they can rely; and there is the extra advantage in this, that the blend which customers are found to like can be more readily continued without noticeable change, although, of course, the ingredients are constantly varying as supplies of particular leaf give out or the character of a new crop changes. Avoid packet teas, and study the water of your locality. Coffee should also be a strong point; like tea, it is one of the things by which customers judge their grocer, and which they criticise among themselves, either to his disadvantage or his good reputation. If possible, the grocer should always roast his own coffee, roasting, if a proper machine be used, being quite a simple process, though demanding skill and care, and when properly performed being a good advertisement, since it gives his coffee the absolute freshness which is so much appreciated. It is by no means necessary to buy an expensive and elaborate roaster; the best in practical use are also the simplest. In addition, a good mill should be employed for grinding the coffee. Of sugar, butter, bacon, and cheese a ten days' supply will usually suffice; of any other goods a month's sales, at most, will suffice. In first stocking, make out a careful list of stock required and get two or three good wholesale houses to quote for cash. On every invoice insist upon a guarantee of purity, such as "All goods named on this invoice are guaranteed genuine," and this must be either signed or initialled in handwriting, care being also taken that the goods are really named, not simply "black" for "black pepper," and so on.

Terms and Discounts. The retailer should always make a point of getting the utmost discount his means allow. Best possible

terms are obtained, of course, by those who buy for cash and in large quantities. So that it is sometimes possible for men in a small way to get level with their bigger competitors by *combining* their orders for certain goods, and "combination buying," especially for certain well-known proprietary goods which everybody stocks, is coming more and more into vogue, often through the medium of the grocers' associations which now exist in so many towns and country districts. Certain goods also are bought subject to special terms and conditions. These particulars are too long to be quoted here; the shopkeeper can hardly carry on his business intelligently without informing himself of such matters by buying and studying the detailed year-books or diaries issued by the trade papers —for instance, "The Grocer" Diary, published annually.

Stockkeeping. Another detail, which is, nevertheless, of great importance, is the keeping of stock and its allocation in shop, cellar, warehouse, or all of these. The details will depend on the accommodation available—the shopfitters will usually be able to give good advice—and a variety of hints on the treatment of the multifarious goods a grocer handles will be found in "The Practical Grocer," a four-volume guide to the trade and allied branches, published by the Gresham Publishing Company. Briefly, the cellar is best for stores of provisions, wines, or goods that require a cool and even temperature. The warehouse with a back entrance should have bins for sugar, etc., shelves for sauces, jams, pickles, unused paper bags, twine, and so on. Note the condition of walls and the relative dryness and heat of different positions in warehouse or shop. If a wall be damp, the shelves upon it are unsuited for cornflour, cocoa, or jam, but may serve for canned goods and mineral waters. Hot shelves near the ceiling are not suited for candles and nightlights. It is particularly necessary that such scented articles as soap or onions should be kept away from goods that readily absorb odours, such as tea, butter, cornflour, baking-powder, and flour. Drawers are convenient for rice, sago, sugar, spices, etc., and should be filled up every morning from the warehouse. Have a place for everything, and keep everything in its place. Weigh, count, measure, or gauge, as required, everything that is bought; neglect of this elementary rule is a fruitful source of loss. Either the grocer himself or a competent deputy should receive and check all goods as they come in, noting and reporting all damaged or faulty goods, or inaccuracies of account or carriers' charges, and so on. A "buying book" should record all goods purchased, with price terms and other remarks, and the stock should be inspected every day that wants may be noted and older goods pushed forward before newer. For heavier goods, such as tea, sugar, rice, cheese, a stock book, or warehouse book, is useful to show weekly the amount of stock, quantity added or sold, and stock at end of week, with such remarks as "sale brisk, prices firm," "price falling, bought too dear." A "wants" book or slate is often kept. In a fairly large shop the "grocery side" may be usefully divided into compartments—say (1) biscuits, jams, canned fruits, patent medicines; (2) cocoas, chocolates, teas, patent foods, extracts of meat, bottled fruits; (3) toilet soaps, perfumes, candles, boot and furniture creams, polishes, and so on.

Account Books. Where a business attains respectable dimensions the proper double-entry system of bookkeeping is always best. But it is certain that very many smaller businesses are successfully conducted without it. A set of books which some grocers find suits their needs consists of (1) journal, or day book; (2) petty sales ledger; (3) sales ledger; (4) purchase book; (5) bought, or merchants' ledger; (6) cash book; (7) detailed cash and credit book; (8) petty cash book; (9) private ledger. In very many businesses conducted on a cash basis, and in some where credit is given, it is found a great saving of time and labour to use "duplicate" or "triplicate" books, so that the first writing of the order provides the necessary record and check slip. There are also several useful "systems" for saving unnecessary repetition and labour in the proprietor's own particular accounts.

Rates of Profit Necessary. In a brisk cash business on a limited number of articles 12½ per cent. gross profit may prove sufficient, while in a credit business, where orders have to be solicited, goods delivered by horse and cart, and periodical accounts rendered, 20 per cent. may be too little. The "Practical Grocer" quotes as results obtained from certain actual experience: Wages, 3½ per cent.; rates, taxes, licences, and insurances, 1 per cent.; lighting, heating, and general repairs, ¾ per cent. paper, twine, pins, etc., 1 per cent.; incidental expenses and depreciation, 1 per cent; delivery of goods, hiring, etc., 1 per cent.; total, 8¼ per cent. But horse-and-cart work alone may account for as much as 4 or 5 per cent. in some businesses. Reckoning rent in addition to the above, and allowing for breakages, spoilt stock, bad debts, etc., interest on capital, and 6 per cent. as a reasonable net profit, it is calculated that from 15 to 17½ per cent. gross profit is needed, and this should be reckoned not on cost, but returns. The grocers' associations commonly advise that even proprietary articles, which are sold in packets and simply handed over the counter as supplied, should show a profit of 15 per cent. for safe trading. In a large grocer's business the percentages of gross profit will probably be as follows: Tea, 16 per cent., stock turned over eight times in a year; coffee and cocoa, 21 per cent., twice to three times; sugar, 2½ per cent., ten to twelve times; biscuits, 11 per cent., seven times; jam, 15 per cent., twice; dried and tinned fruit, 15 per cent., three times; green fruit, 14 per cent., weekly; soap and candles, 21 per cent., three to four; small grocery sundries, edible, 20 to 30 per cent., twice; household sundries, non-edible, 20 to 30 per cent., twice.

Assistants. The number of assistants varies greatly, of course, according to the nature and requirements of the business. A small grocery shop may be run by the proprietor himself with the aid of a single assistant and a boy. In a typical London shop there may be, say, five grocery and two provision assistants, a clerk or bookkeeper, cellarman, vanman, and porter. In a typical good class grocery and provision shop in the country there may be a "first hand," or "manager," two other assistants—one of whom is a "provision" hand—an apprentice, a porter, and a couple of errand boys. "Living in" is becoming less and less common. Where the men live out an hour for dinner and half an hour for tea is usually allowed. Managers give or receive a month's notice; other assistants commonly a week. In many shops rules are enforced, each assistant being obliged to hold a copy and to give his written assent to them. Fines are only deducted legally when the assistants have thus assented. A grocer's assistant is not a "workman" within the meaning of the Employers and Workmen Act, but comes under the Truck Act.

Side Lines. Provisions are most commonly sold in the same shop with groceries. They are discussed in a separate article in this course. Other side lines and allied trades or branches of the trade are, as indicated above, very multifarious. Oils, fermented liquors (with licence or licences), tobacco (with licence), china and earthenware, patent medicines (with licence), and green fruit may be mentioned. For hawking any groceries that are not victuals a hawker's licence is needed.

Cash and Credit. Many grocery businesses are now conducted on strict cash lines; but mixed cash and credit is very common. In a "family" business, in which profits are commonly good, it is often next to impossible to insist upon cash, and a credit trade, conducted with caution and due inquiry, is found steady and lucrative. It is wise to be on one's guard against the prevalence of fine furniture supplied to needy debtors on the hire system.

Laws and General Policy. The Food and Drugs Acts, Margarine Act, and Merchandise Marks Acts, which are more fully dealt with in the article "Provision Trade" [*q.v.*,] are mainly those which apply to the grocer's business. As regards his shop, he has to pay attention, as a matter of course, to the laws on shop hours, seats for assistants (females), children, sale of goods, weights and measures, and so on. A special point is that of weighing paper with goods, which so far seems to be allowable when the goods are such as are commonly sold wrapped in paper, provided that the paper is of reasonable weight and thickness; it is not permissible to sell a great quantity of tea-lead at the price of tea. Under the Food and Drugs Acts goods that are mixed, such as coffee and chicory, may be sold provided there is a declaration to the purchaser, which may be by means of a printed statement on the wrapper. But the added article must not be such as increases the bulk fraudulently. In the case of coffee, it would cease to be even conventionally called "coffee" if more than 50 per cent. were chicory; it would then become chicory to which coffee was added, rather than vice versâ, and should be labelled "chicory with coffee." But the whole of the Food and Drugs Acts should be carefully studied by every grocer. In his general policy his whole aim should be to give his customers intelligent, honest, civil, and efficient service; he should try to make his own personality so acceptable and useful to them as to outweigh the advantages he cannot command, since at large stores the lower working expenses and the ability to buy better are sometimes counterbalanced by the necessity of employing none but paid assistants, who have not the proprietor's keen personal interest in their work. A well-trained, well-informed, intelligent, and energetic grocer working his own shop at a reasonable rate of profit can usually do something more than hold his own, no matter what the competition.

Trade Instruction. An excellent course of technical instruction for those engaged in the grocery and provision trade is given at the Borough Polytechnic Institute, London, and should be taken advantage of by every ambitious grocer who can make it convenient. The course consists of over 20 lectures, beginning in the month of October, and the cost of attending the lectures is 7s. 6d. The scope of the instruction will be best indicated by giving a synopsis of the subjects:

GROCERIES

TEA, COFFEE, AND COCOA. Countries of origin and kinds, preparation, shipment, market and prices, blending and preparation for sale at home, relation to waters of different districts, judging of quality and value, practical tests for purity, etc. Special attention to the detection of adulterants.

SUGARS, CEREALS (rice, tapioca, sago, flour, and various meals), DRIED FRUITS.

PROVISIONS

BACON, HAMS, AND CHEESE. Various cuts, character of the supplies from different countries, processes of preparation for market and their comparative effect on the value of the product, method of handling so as to show a profitable result.

BUTTER, MARGARINE, AND BUTTER SUBSTITUTES. The chemistry and natural history of butter; judging its value, keeping qualities and specially its purity, freedom from excess of moisture, artificial colouring, and preservative and adulteration.

TRADE LAWS

GENERAL. Landlord and tenant, method of holding property, taxation and rating—the Income Tax, duties and licences, master and servant agreements, recovery of debt, bankruptcy, etc.

SHOP MANAGEMENT AND ROUTINE

SPECIAL. The Food and Drugs Act, the Margarine Acts, the Shop Hours Acts, etc.

Buying and stockkeeping, window dressing, staff management.

The lecturers are successful practical experts in the subjects which they teach, and no grocer can attend the classes without learning much regarding the science of his trade.

The Licensed Grocer. Many grocers are also wine and spirit merchants, or sell beer for consumption off the premises. So far as England is concerned this branch of the trade

was greatly developed as the result of Mr. Gladstone's action in 1860, when he reduced the duty on the light French wines, and created a new licence to enable those wines to be distributed by the grocer rather than by the older branch of the licensed trade. The capital required for such a branch of the grocery business, or even for an off-licensed business as a sole trade, is not very large; and the facilities offered by the large wholesale firms enable it to be prosecuted without any difficulty. Some of these firms will not only supply the liquor in bottles ready for sending out, but also procure the licences necessary. It is this simpler branch of the licensed trade with which we are here chiefly concerned. To conduct a business in which wines or spirits are bought in the wood and bottled by the merchant himself requires not only capital but very considerable experience and training. It should be noted that in the licensed trade each part of the United Kingdom has its own special laws and licence regulations—and these laws are not only numerous but in many points involved and intricate.

Licence Needed. No person can carry on a business in intoxicating liquors without (*a*) a licence from the magistrates; (*b*) a licence from the Excise and Inland Revenue authorities. The magistrates' licence is granted at a special session held in February each year. Before appearing to apply for it the applicant has to give and to publish various notices. He has to give notice to the overseers of the parish where his shop is situated, and to the Superintendent of Police; and to exhibit a notice on the door of the premises, on the church door or some conspicuous place if there be no church, and also in a local newspaper. If the magistrates grant the licence it has to be confirmed at another meeting of the justices, and in granting or refusing it the justices have absolute discretion, while the applicant must not only prove the publication of his notices in due form and at the proper time and place, but must produce evidence that he is a person of good character; and in view of the probability of opposition, he also, as a rule, deems it prudent to produce a memorial or petition to the effect that the licence for his shop is desired in the neighbourhood. Having run this gauntlet and obtained the magistrates' permission to hold his licence or licences, he has to apply to the Inland Revenue Commissioners for the licences sanctioned. A grocer may obtain licences, all or any, for (1) the sale of beer and porter for consumption off the premises; (2) the sale of wine off the premises; (3) the sale of spirits off the premises. In 1906 the Excise Duty (annual) for the off beer licence was £1 5s.; the off wine licence £2 10s.; and for the off spirit licence an amount ad valorem, according to the value of the premises. This latter licence permits the licensee to hold off beer and wine licences without further payment of duty.

Regulation of Premises. The grocer holding any of these licences is bound to obey the provisions of the Licensing Acts so far as they apply to his particular case. He has to be very careful, of course, as to the hours in which his premises are open for the sale of intoxicating liquor. In a town he must close at 11 p.m. and not open before 6 a.m.; in a village he must close at 10 p.m. On Christmas Day and Good Friday also his premises must be closed; and on Sundays there are special hours only on which they can be opened. If a grocer wishes to keep open his shop for the sale of groceries after the hour at which the law obliges him to close the sale of liquors, he is obliged to cover up the liquors in some way so that they are not "exposed for sale," as either exposing or selling them would cause him to incur serious penalties and risk the loss of his licence altogether. It is also very necessary to take care as to the quantity of liquors sold, this being a point minutely specified according to the licence held; and again as to the non-consumption on the premises; while if there be branches, the grocer has to take care that the orders are not accepted there (if they be not specially licensed), but merely forwarded to his licensed shop to be accepted or rejected there and the liquor appropriated there to the customer according to the order. Detailed instructions as to how to apply for and obtain the licences, and the law as to the points to be observed by licensees, such as are referred to above, are given in such trade annuals as "The Grocer" Diary.

Shop and Window. In the shop the fittings for an off-licence business need not be expensive—a few racks and shelves for bottles and a window or part of one. A few attractive shop and window bottle display stands are shown in the accompanying illustration [2]. The bottles should be displayed neatly and attractively and showcards kept in evidence. If there is a cellar the greater part of the stock should be kept there; if not it has to be provided for in the shop as best may be. In that case bottles of wine should be stored as near to the floor as possible, to avoid unevenness of temperatures; and the bottles should always be placed on their sides and not standing up, as the corks of bottles of wines that stand up become dry speedily and the wine at once deteriorates. For this reason only empty bottles of wines and "dummies" should be used for a window display, the wine itself never being placed in the window. With regard to bottles of spirits, these can be used for the window or shop at will, and are better standing up than lying on their sides. Bottled ales and beer should also be kept upright. In passing, we may note that the legal term is "beer," which includes ale, porter, stout, spruce beer, black beer, or any other description of beer which contains a greater proportion than two per cent. of proof spirit. Even herb beer, ginger beer, hop ale, etc., are deemed to be beer, and come under the licensing laws if on analysis they are found to contain more than that amount of alcohol; so that small shopkeepers are sometimes fined for dealing in such "intoxicating liquors."

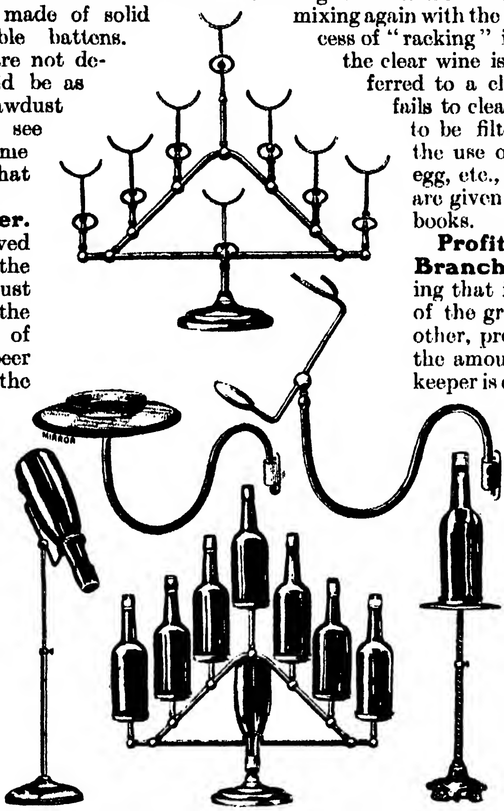
Cellar Storage. The cellar should be bricked round, with concrete floor, cool and

well ventilated so that the air shall be pure, but free from draughts. It should be kept clean and sweet by giving walls and ceiling a good coat of limewash at least once a year, and having the floor swept and sawdusted nightly. A little chloride of lime mixed with the sawdust is desirable in summer. In a cellar the great desideratum is an even temperature. Beers keep best at a fairly low temperature; about 55° to 60° F. is found suitable for cask and bottle alike. Port wine does best at about 58° to 60° F.; lighter wines at a rather lower temperature. For stands and bins iron is best. Casks should be placed horizontally, a few inches above the ground, on what are called gauntrys, which are best made of solid concrete or framed double battens. Those gauntrys with legs are not desirable, as the cask should be as rigid as possible. When sawdust is put down in the cellar see that it is not allowed to become damp and to stay in that condition.

Treatment of Beer. When a cask of beer is received it should be placed on the gauntry in a position with just sufficient cant to allow all the hops to settle in the bulge of the cask and to allow the beer to be drawn off clear by the taphole. Then, with a large gimlet bore a hole in the highest part of the cask just behind the bung and in a line with it. In this place a vent-peg or "spile." This peg should be eased out carefully each day to allow the gas generated in the cask to escape, and then replaced; but care should be taken not to leave it out so long as to let the beer get flat. Beer brewed in March or October usually improves in quality, and keeps better after bottling if allowed to rest at least six weeks on the gauntry before bottling. Summer-brewed beer should be bottled off as soon as the beer becomes bright, which is in ten or fourteen days.

Treatment of Spirits. Brandy, rum, and whisky are not allowed to be sold (except as "diluted spirits") at a strength lower than 25 under proof—*i.e.*, they must contain 75 per cent. of proof spirit. Gin may be sold as low as 35 under proof, though a good gin should be 20 under proof. ("Proof" means the strength of spirit as ascertained by Sykes's hydrometer; and by weight "proof" consists of 49·24 parts of alcohol and 50·76 parts of water.) In cask, spirits are often sent out considerably stronger than the above figures indicate and may, therefore, be "reduced" by the retailer, who adds to them water as required, taking care that he does not bring the strength below the legal limit. Tables for "reducing" will be found in such trade handbooks as the "Wine Trade Review" Whisky Guide.

Treatment of Wines. Wines in the wood require very careful treatment, being very sensitive to any change of temperature. The cask should be placed on the gauntry as nearly horizontal as possible, in order that the "lees" may collect in the centre of the cask. The "lees" is the solid matter which is held in suspension, and by depositing which the wine clears itself. Sharp changes of temperature disturb the wine and cause the lees to rise again. For this reason, to prevent the lees mixing again with the cleared liquor, the process of "racking" is resorted to—that is, the clear wine is drawn off and transferred to a clean cask. When this fails to clear wines they may have to be filtered and "fined," by the use of isinglass or white of egg, etc., as to which directions are given in various trade handbooks.



2. SHOW STANDS AND BRACKETS FOR BOTTLES

Profits of Licensed Branch. It goes without saying that in the licensed branch of the grocery trade, as in any other, profits run according to the amount of skill the shopkeeper is called upon to exercise in handling his goods. As indicated above, the business can be conducted in different ways: (*a*), as an agent, with a minimum of trouble; (*b*), buying goods in bulk and retailing one's own brands; (*c*), as a full-blown wine and spirit and bottled beer merchant, keeping a fully-stocked cellar and handling a large stock both wholesale and retail. The profits will naturally be in proportion — small for (*a*), where little risk is taken and small skill required; larger for (*b*), in which both elements are increased; largest for (*c*), where the greatest expert knowledge and highly trained skill are required and brought into play. In the space at command we can hardly pretend to teach the whole art and mystery of judging vintages, blending spirits, and so on. But it may be useful to note that even (*b*) as a mode of conducting the licensed trade shows substantially better results than (*a*), the simplest form of that trade. Thus, the bottling of wines may show 25 or 30 per cent. profit on returns, instead of less than half that percentage. To *brew* beer for sale, we may note, a special licence is required, and duty has to be paid upon the beer itself.

Continued

Continued from page 2797

HEALTH AS CAPITAL

Nature and Production of Vital Force. Causes of its Variation in Amount. Preservation and Expenditure of Our Strength. Health Paupers

By Dr. A. T. SCHOFIELD

IT is necessary to inflict one more financial chapter on the reader in order to bring home to him the real analogy there is between health and wealth. There is indeed amongst a vast number of the population more than an analogy, there is an actual substitution of the one for the other, for there are numbers of working men, who form the very backbone of their country, whose *only* wealth is their health, and who can, therefore, so well understand the terms here used, seeing that their daily vital force is their sole income, their reserve of health their sole capital. How important, therefore, it is that the working man should understand how to take care of the one, and to rightly spend the other. Though a sound practical knowledge of personal hygiene is essential to all, it is of far the most value to those who know *no other wealth than health*, and to whom its loss is nothing less than a calamity, and spells bankruptcy in every sense of the word. We have spoken already in general terms of health finance; we will now consider the question of *capital and income*.

Capital. Capital is the reserve force that constitutes sound health. A hand-to-mouth existence without capital is not consistent with a healthy life. A person who leads such a life is absolutely dependent from hour to hour on the food he takes, without which he would utterly collapse. This is not health; for while a strong man requires food, he is not dependent upon it in the same way at all. The author had before him, for instance, the other day, a brisk, energetic man, over 5 ft. 9 in., and weighing under 8 st. He came to consult about some special symptoms of nerve trouble, but otherwise was in what he called "good health." Here, then, was a man with no capital, dependent from hand to mouth on his food force—one walking gaily along the edge of the precipice, who *might* walk there safely for some time, but who, on the other hand, *might not*, for the smallest push from any sudden disease would assuredly send him over. There are many such, making a brave show with practically no capital. On this reserve force or capital, then, depends the duration of our happiness and health.

Life Force. The next point is to understand a little more about our life reserve force. As regards *length of life*, this depends, as we have seen, upon heredity, and can be roughly calculated, but the *amount* of life force depends upon ourselves.

The period of growth is the real time when it is being stored, for although force at this period is largely spent in building up the body, it is produced so rapidly that capital is quickly accumulated. During adult life it can also be stored more slowly until forty-five or fifty; but from that time it is spent a little faster than it is made, and is gradually used up in old age as income, until when a person dies a natural death hardly a (health) shilling should be left in the bank. Those who die prematurely die with much unspent capital, which is wholly wasted. Of course, the need for storing up capital in youth shows as nothing else does the importance of avoiding a drain on our resources at this time by youthful excesses; for there is no doubt whatever that a fast life is a short life and an unhealthy one, and not only can the store we accumulate thus be quickly dissipated, but the life itself ends in a premature bankruptcy. Our stock of vitality in relation to length of life is strictly limited, and though we may slightly prolong it by care, we can much more easily shorten it by excess.

Although we have given a table to calculate roughly the *duration* of life force, we know no way of computing its *volume* or amount during life. We can, of course, tell practically when it is running short, because our cheques are not honoured, but returned marked "No assets." In other words, we are easily tired in body and mind, and cannot recuperate as we should do.

The Body's Many Systems. Let us now touch on another point concerning capital, and for this we must cease to regard our personality as one, and look at ourselves as a community of seven or eight systems—the nervous, locomotor, digestive, circulatory, secretory, respiratory, reproductive, etc., each with its own banking account and its own separate capital, which, moreover, *cannot be transferred*, save quite exceptionally, from one account to another.

Thus, if a man has spent all his respiratory force, he really cannot make it up from any other system. If his nerve capital has run out, it is little consolation that his locomotor account shows a strong credit balance. He cannot transfer his reserve of respiratory food to an exhausted digestion, nor can the bankruptcy of a worn-out heart be averted because the secretory system is solvent.

The total health of the individual is, of course, made up of the reserve capital of the different systems; but the bankruptcy of an important system may mean the death of the man; or, if the ruin is only partial, his ill-health at least.

Reserve of Nerve Force. We shall point out the different values of the various capital funds, and, above all, the pre-eminent importance of nerve reserves. Health, and even strength of body, are really valueless if there be no nerve force to spend it; and while, on the one hand, we must fail if our heart capital be all spent, we can often live a long time if the nerve system be solvent, though many

other systems be well-nigh bankrupt. Of course, capital has a different importance at different times. The reserves in the vaults of the Bank of England might almost as well not be there in specie for perhaps fifty-one weeks of the year; it is on the fifty-second, when the run on the bank comes, that they have all their value.

Inroads of Disease. And so it is with multitudes around us. Numbers are what Sir B. Ward Richardson used to call the *morituri*, or those liable at any time to death, simply because theirs is a hand-to-mouth existence. We have given an example of such an one. Others are doing very well, because the times are quiet and healthy; but let a sudden run on the bank come in the shape of strain or shock, and the bank breaks at once; whereas, on the other hand, if the reserves are strong, the drain of minor diseases is hardly felt at all, or they pass us by as too strong even to be attacked. Banknotes owe all their value to the solid reserve of specie in the vaults, and are worthless without it; and that health which does not rest on a solid reserve of force in each of the various systems of the body is only like so much paper currency.

One last thought before we leave this general survey of capital. It is of the utmost importance in any run on the bank, in sickness of any sort, not only that it should be promptly met, but that the excess of capital paid out should, as soon as possible, be replaced; in short, that the man should not be content with the sickness being stopped; he must have his full health and strength restored. Hence the *supreme importance* of a thorough convalescence.

There are in health, as in wealth, *three classes* of people—those who *live beyond* their income, those who *live up to it*, and those who *do not spend it*. Before considering these classes, let us look for a moment at what in life represents *income*, as opposed to capital.

The Daily Amount of Our Strength. The average amount of food consumed by the average man at average work produces in or about 3,400 foot-tons of force daily. (A foot-ton is a ton raised 1 ft. high.) There is no need here for any greater accuracy, for what we want to understand is the principle on which we live, and not the exact details in figures.

Now, what is meant by the above? Let us briefly explain. To lift a ton, or 2,240 lb., 1 ft. off the ground requires a considerable amount of force. The combustion of food daily, combined with the oxygen we inhale, sets free from the service of the body daily 3,400 of such foot-tons. This force may be used as motion, heat, or in other ways. As a matter of fact, it is found that about nine-tenths of it is used unconsciously for the warming of the body, and for the maintenance of life, making good the wear and tear of the body, and manufacturing the various complicated products necessary for its existence, as, for example, a gallon of gastric juice and a quart of saliva daily.

This leaves us some 300 foot-tons of force still available for use consciously in any way that the will of the person pleases—in moving the body about, including the tongue, as much or as little as we please; also in thoughts and emotions, which are expensive—in short, in living.

Economical Expenditure of Force. So that it appears that an average man in perfect health has a large income, of which, however, he can consciously control the expenditure of only about *one-tenth part*.

Considering this world for a moment as our school, we may say that an all-wise Creator puts into the hands of His creatures 300 foot-tons of force each morning as pocket-money—He meets all the school bills with the rest—and the way we spend it, wisely or foolishly, or hoard it, do good or evil with it, displays our character.

The income, then, of which we principally speak here is that tithe that is at our own disposal, and, as we have said, we may *exceed it, live up to it, or live below it.*

Those who exceed it are in danger, because to exceed income means to trench on capital—for in life there is *no credit* given, no getting into debt with others. We must pay our way, and if we get into debt, it can only be with ourselves by spending our principal, which is the way that leads to ill-health and death or bankruptcy.

Those who live up to their income and leave their capital untouched, are the wise, the happy, persons in perfect health; while those who live below it and try to save it, find that health cannot be hoarded, and that unspent income soon leads to ill-health, not through starvation, but plethora.

We must, then, be neither misers nor spendthrifts if we would be healthy, but use wisely and well what is given us to spend, be it much or little; and while looking on health as well as on wealth as a good gift of God, we should never regard its accumulation as the object of life.

To spend the whole of life in acquiring health and strength, and to die without using the one or the other for any wise or useful purpose, is like amassing riches and having to leave them unspent and unused.

Approximate Daily Expenditure. But since living up to and not beyond our income —here set down at an average of 300 foot-tons— be such an advantage, is it not of the first importance to have some means of knowing whether we are doing so or not? Undoubtedly it is. But inasmuch as we cannot count our foot-tons as we can sovereigns in our pockets, we can only estimate our expenditure approximately.

If we spend what mental and physical force we have without strain each day, in order to produce a healthy fatigue of mind and body, which entirely disappears in sleep, so that we rise fresh and well; if we are conscious of no running down in weight or in our powers, especially of nerve force; if we have not to use any stimulants of any sort to keep up our energy, then we may justly believe we are not exceeding our income nor trenching on our capital. The man who habitually lives beyond his income needs stimulants, which, indeed, are but *drafts upon his capital* or reserve force.

But why should any live extravagantly since doing so can only bring disaster upon themselves?

From several causes. In the first place, there is a large class of people who are in a distressing position through poverty, which obliges them to spend all their income in earning it; and even then, with all their efforts, they cannot quite earn what they are obliged to spend, and hence are perpetually overstepping their limits through sheer necessity.

Health Paupers. These form our large army of workers for their daily bread, who often find great difficulty in providing what are called the necessities of life—*i.e.*, the 3,400 foot-tons the body requires for its maintenance. Indeed, their life is peculiarly hard, for the work they have to do is so arduous that they require far more foot-tons of force than the average man, and thus they fall short through insufficient food. We cannot call such people extravagant; they call for our sympathy and help, which can be best given by showing them how to economise force, and how most easily to generate it. Many thousands are in poor health, and many thousands die in consequence, because they live in such circumstances that good health cannot be maintained. They are obliged to become health paupers. But we do not write only for this distressed class, but also for those who, with a good income, often entirely provided for them without effort of their own, are free to spend it all, or nearly all, in any direction they please, and are at no time under the necessity of exceeding it. Why, then, should such ever be extravagant?

The motives, indeed, differ widely, though the results are the same. But although it is true that Nature takes no account of motives, and considers only the "what" and not the "why," and visits all extravagances with the same penalties, there is no reason why we should not consider them.

Health Spendthrifts. There are those who exceed their daily health income, as we have said, from a spirit of emulation or pride. They wish to show they are as rich and strong as others, and to such an extent will some go in keeping up deceptive appearances of being "grands" when they were never made for anything but "cottage" pianos, that, like the traditional "soldier" who lived on his pay, they "spend a half-crown upon sixpence a day." You will see a girl, with perhaps but 150 foot-tons of force for her daily pocket-money, emulating in all things her brothers, who have 300 or more to spend.

What would be thought of an engineer who drove his engine to double its power? The result would be the same as with a human being who spends double his health income—a complete breakdown.

Others are extravagant simply because their tastes and wants are expensive, and far beyond their income. Where fashion is concerned, for instance, all questions of health finance, if they ever exist, are forgotten; and if its votaries are required to live at high pressure through a London season, they are very near bankruptcy at the end; hence the almost universal custom with such of a "cure" at some foreign spa in the autumn.

Many, through love of pleasure, fashion, or sport, or even from restlessness of disposition, are living at this extravagant rate, and make a great display of energy and health; all their goods, as it were, are in the shop window, without reserves behind.

Others, again, are extravagant from some fixed purpose for God or man. These set out quite prepared to suffer in health, even, if needs be, to lay down their lives in fulfilment of their call or mission.

As we have said, the reasons for extravagance differ immensely morally, but physically the result is the same. To God the motive is everything, to Nature nothing. The vicious man of pleasure and the overworked missioner both pay the penalty if they make reckless drafts on capital.

Live Cheaply and Naturally. Of course, the cheapest way to live is to live easily, and well within the limits of exhaustion. Fatigue is good, exhaustion bad. Life is so largely a matter of habit and temperament that many live healthily and wisely in a way that would kill others. We know one doctor who does all his hard study between half-past five and half-past seven in the morning, going to bed, of course, soon after nine, for the rule against burning the candle at both ends is one of the few that are well-nigh universal. Early rising, however, by no means makes all men either "healthy, wealthy, or wise." Many can work much more economically and easily at night than in the morning; all depends not only on the individual, but on the character of the daily occupation. That life is easiest that is most in harmony with our environment.

On the other hand, what does spend force with wasteful rapidity is hard work under severe mental shock, or when weak bodily, after some severe illness or under great pressure without sufficient rest or change. Working really "against the grain" is nearly always expensive. All forced labour is unhealthy.

Sudden changes of surroundings or occupation are often fraught with danger, and many men can no more bear transplanting after a certain age than some trees. Habit counts for so much.

We cannot overrate the importance, if there be a strain, of putting it always on the strongest and not on the weakest parts of the body. If, for instance, the brain is strong and the heart weak, do more head work, and less paid manual labour, and so on.

There is one form of spending which only makes us the richer and stronger in the practice. There is an income that only grows as it is spent, which we can never exhaust. It is well indicated in a book called "In Tune with the Infinite"; and the principle of it is simplicity itself. Once we are really in touch with a source of infinite energy and love, we can *give, give, give*, and be none the poorer. In the sphere of spirit life, at any rate, we are free from the care of ever being beggared.

Continued

RAILWAY CONSTRUCTION

Considerations in the Inception of a Railway. Potential Earning Powers and Costs of Construction and Maintenance

continued from page 2889

By R. W. WESTERN

THE objects for which railways have sometimes been built are very diverse, and include military and political objects. Many railways in Russia and other parts of Europe and in India have been constructed with a single eye to the movement of troops in time of war. Other railways, of which the Canadian Pacific Railway is an example, have been initiated, if not maintained, to effect or consolidate the political union of the countries or provinces through which they run. The Uganda Railway has been built to introduce civilisation into that part of Africa, and in numerous instances, particularly in British India, there are railways the construction of which would have been indefinitely postponed, if not utterly abandoned, had it not been for the necessity of providing work for a famine-stricken population.

All these examples of railway building, though their existence should be borne in mind, are in their nature exceptional. The main object of railway building is to supply a commercial need in return for a commercial recompense. The great majority of railways are built with this object alone, and there are no railways, even among those referred to, which have not been built with a careful regard to this end.

What a Railway is. A railway may be regarded from more than one point of view. Considered merely as a physical entity, it may be defined as a roadway adapted for the exclusive use of vehicles provided with flanged rails. This definition would also include street railways, or what we now call *tramways*. A railway as understood in this country is confined to ways with rails raised above the level of the ground. A railway may also be regarded as an economic organism; and this is an aspect that must never be lost to view, since upon the success or failure of a railway as an economic organism its expansion or decadence as a physical entity depends. Economically considered, a railway is simply one of the numerous organisations necessarily evolved by all civilised communities for the purpose of carrying its members and their goods.

If successful, it will develop and expand as the numbers and wealth of the community grow, and its success will depend upon the efficiency with which its functions are performed in competition with other railway organisations and with different forms of locomotion.

Competition. When once it has been ascertained that a district affords sufficient traffic to justify the construction of a railway, there is no other consideration of such far-reaching importance as that of the competition which may immediately or ultimately arise.

The profits to be derived from a commercial undertaking can under ordinary circumstances never exceed greatly that of the usual return from other enterprises of like standing, since if the profits are much higher, competitors will be attracted to its particular sphere of activity, and thus tend to reduce the profit to a more usual level.

Exceptions occur when the enterprise is in some way protected from competition, whether by law or from physical causes.

When the line of an existing railway occupies the only feasible route between two or more centres of population it is protected by physical causes from the competition of other railways, and, to a great extent, from the competition of other forms of land locomotion. In default of an only feasible route, if a railway occupy the best possible route which the topography of the country affords, a great measure of protection will be secured. By this it will be seen how important it is, in fixing the line of a new railway, to discover and decide upon one which is not merely good enough, but as nearly as possible the best.

The Land Occupied. The ground over which a railway runs is for ever spoiled for any purposes other than a road. This is one of the serious risks of railway enterprise. In almost any other kind of commercial undertaking the land purchased can, in the event of failure, be sold without any great loss of value. Even a canal may be converted into a railway. Many have been so converted. But a railway cannot be converted into a canal. The possession of land gives to the railway—that is, to the railway organisation—occupying it, the rights of a landlord in the monopoly of its use. Such rights unmodified would afford a very strong protection against competition of all sorts. But since the land required for a railway is a long thin strip which it would in almost every case be impossible to acquire without the assistance of the Legislature, the authorities, in granting the necessary powers, are always able to stipulate for such modifications as may seem necessary for the protection of the public.

Concession or Act of Parliament. The legal enactments enabling the construction of railways are treated in PARLIAMENTARY SURVEYING [page 1237].

It is sufficient to point out here that the terms of the concession necessarily exercise a very important influence upon the general plan and details of construction and equipment. The maximum rates for passengers and for the various classes of goods are usually fixed, together with a number of physical quantities, among

which the most important are the gauge, or width of the road, the greatest permissible gradient and sharpness of curve; the minimum distance at which the trains may be allowed to pass buildings, signal posts, and other trains; the lowest height at which the line may pass over public roads and rivers, etc. Such stipulations may, and often do, materially restrict and hamper the engineer in his choice of expedients.

Nature of the Organism. An undertaking of the magnitude and national importance of a railway can very seldom be the work of one individual, but must in practically every instance be done by the public for the public. Certain members of the community will specialise themselves for the purpose, devoting as shareholders a part of their property to carrying it out, or, as employees, their time and labour to carrying it on. Others, as customers, will contribute some of their means in order to participate in the benefits it affords.

The ordinary form in which the revenue account of a railway appears shows how the services rendered and the sacrifices made by the different groups of persons are balanced one against the other, of which we give a condensed summary:

Revenue Account.

Dr.		*Cr.*	
	£		£
Wages and materials ..	582,000	Traffic Receipts ..	964,000
Dividends and Interest ..	382,000		
	£964,000		£964,000

The *traffic receipts* are contributed by customers. *Wages* (and if the railway be great enough to mine and manufacture for itself, the item *materials* also) are the remuneration of employees, while *interest and dividends* are the recompense of those who have sacrificed their property for the construction or development and expansion of the railway.

The Working Ratio. The ratio of the wages and material to the traffic receipts, obtained by dividing the former by the latter, is called the *working ratio*, and is usually presented as so much per cent. The working ratio in the present instance is 60 per cent., a very usual figure in Great Britain.

The following is a list from the principal countries for which railway statistics are available of the working ratios that obtain in each instance:

	Per cent.		Per cent.
Australia ..	68	Holland	66
Austria-Hungary	65	Ireland	62
Belgium	61	India	44
Canada	64	Italy	75
Cape Colony and Natal	71	Roumania ..	59
		Scotland	54
Dutch Indies ..	57	Spain	47
England and Wales	63	Switzerland ..	57
France	52	Turkey	50
Germany ..	65	United States ..	65

It will be seen that this most important relation is a very variable quantity. In the language of elementary algebra we may say, if R represent the traffic receipts of a railway—*i.e.*, the amount shown on the right-hand side of the revenue account, of which an example is given above—and X and E represent the amounts of the two groups of items brought together on the other side of the account, in the order given, then $R = X + E$, since the two sides of the account must balance.

The working ratio, to be represented by η, then becomes equal to $\frac{X}{R}$, and $\frac{E}{R} = 1 - \eta$, where E represents the net earnings. But it has been shown that E, the recompense for investment of capital, tends, under the influence of competition, to become a proportion thereof approximating to the rate of return upon capital invested in other business of equal standing.

This tendency may be exhibited by actually equating the two, and we have $\frac{E}{C} = \frac{J}{100}$, where J is the per cent. of the rate in question, or the value of money for commercial purposes in the country at the period considered. Multiplying both sides of this equation by $\frac{R}{E}$ we obtain

$$\frac{R}{C} = \frac{J}{100}\cdot\frac{R}{E} = \frac{J}{100}\cdot\frac{1}{1-\eta}.$$

Thus, the very important quantities R, C, J, and η constantly tend towards values the relation of which is conveniently expressed by the equation $\frac{R}{C} = \frac{J}{1-\eta}$, where η as well as J is expressed in per cent.

In Great Britain, as a whole, the working ratio has risen from under 50 per cent. during the sixties to over 60 per cent. at the present time, this change being in a great measure accounted for by the diminished value of money, as above explained.

Cost of Construction. Before going further, it will be desirable to form some idea as to the cost of a railway. Anything from £4,000 to £60,000 or even £100,000 per mile, though true, is rather too vague for our purpose. It is important that anyone engaged in railway work, immersed in detail—as, of necessity, he usually is—should retain a clear vision of the cost of the whole, as well as its objects and function, in order that he may not be at fault in estimating the value and the relations of his particular part.

$$£ \times \text{lb.} + 10 \times \text{lb.}$$

is a formula easily remembered and applied. The symbol lb. here represents the number of pounds avoirdupois which one yard of the rail used will weigh, and the symbol £ the number of pounds sterling that the rails cost per ton delivered.

This quantity doubled will give approximately the least cost of the permanent way of a single line of railway per mile of open line in sovereigns. The formula is not intended for practical use, but merely to fix ideas. The *permanent way*

includes the rails, the chairs which support the rails, the sleepers to which the chairs are fixed, the broken stone or ballast upon which the chairs are laid, together with the bolts and other fastenings, for main line and sidings.

The *earth work*—the cuttings and embankments upon which the permanent way is laid—together with the necessary bridges, etc., will cost in a moderately undulating country about the same, and the necessary buildings and other works a similar amount. The minimum of equipment—*i.e.*, the engines and vehicles—will probably come to less, say

$$\tfrac{2}{3}\ \{\text{lb.} \times £ + \text{lb.} \times 10\}$$

But the cost of obtaining the necessary legal powers to build, and the expenses of acquiring the land, cannot be included in a general statement.

The approximation of the results of this formula to actual figures depends upon the fact that, in a well-designed railway, the weight of the rails per yard of length is to some extent a gauge as to the number and size of the sleepers taken, as well as to the amount and quality of the ballast beneath them; while the cost of the rails per ton delivered is a rough measure of the whole cost of the material utilised, as well as of the expense of doing the work. As a rule, the heavier rail is associated with a more level road, and therefore with more earth work.

According to the formula the permanent way of a single line of railway with 80 lb. rails at £6 per ton would be:

2 (80 × 6 + 80 × 10)		
= 2 (480 + 800)		
= 2 × 1,280, or ..	£2,560	per mile.
Earth work, etc. ..	2,560	,, ,,
Other works	2,560	,, ,,
Total cost of road	£7,680	,, ,,

With 30 lb. rails it would come to about half, as the cost per ton would be rather more. Neither of these figures are very far from the average results of actual working.

Estimation of Receipts. The main factor in deciding the construction of a railway is the amount of its estimated annual traffic receipts. The cost of construction comes second, as this can be modified in various ways in order to deal with the greater or less amount of traffic.

Numerous formulæ have been invented for determining the receipts to be anticipated from a proposed railway, all of which, however, have but a local, or very restricted, application.

In settled countries the density of population, or the number of inhabitants per square mile, in the district through which it is to pass is the basis in every case. In new territories the estimate involves a further estimation as to the amount of immigration and probable commercial development.

In all cases comparison must be made with other districts as nearly like it as circumstances permit, and the estimate calculated on the assumption that the local traffic receipts per mile of line will vary directly with the density of population and with the area served. The through traffic, which is derived from other railways, or the seaboard, etc., will usually be of a competitive character, and will depend upon the special facilities that can be afforded.

The chief difficulty consists in finding suitable subjects for comparison. The demand for railway accommodation depends chiefly upon the industrial development of the population. When a number of self-providing families occupy the land, there is little occasion for wholesale carriage except of passengers for pleasure. But where the land is occupied by numerous communities, each devoted to some special production, the materials for which and the results of which they exchange among themselves or with foreign countries for mutual consumption, a very high contribution per head will be made to the traffic receipts of the railways. The extent to which this specialisation of employment is carried is also dependent upon the density of population when other circumstances are similar; consequently the traffic receipts of an established railway tend to increase in a geometric ratio rather than in an arithmetic ratio to the density of population. Often the traffic receipts will be found to vary approximately with the density of population squared.

The method of estimating the probable traffic receipts of a railway by careful calculation of the output of mines and factories, etc., both actual and potential, accompanied by the detailed compilation of road statistics—*i.e.*, the number and character of passing vehicles—is extremely laborious, and no more certain than the foregoing method, since the amount of such traffic that can be diverted to a railway remains a matter of conjecture. It is, however, useful as a check upon the former.

Working Cost. It has already been pointed out that the establishment of a railway is the result of a public effort to provide a public service of locomotion. The effort is made in two ways. The first is measured by initial capital expenditure, and the second by the annual working expenses, the amount of which we shall now consider.

The chief thing to remember is that the whole aim and object of the first is to diminish the amount of the second. This point will be developed later. For the present purpose it is sufficient to note that every detail of the construction of a railway must be studied in respect to its influence upon the ultimate amount of working expenses, having regard to the kind of work—that is to say, the description of service—the railway is constructed to afford.

The railways of the United Kingdom began the present century—to take a conspicuous date—with a cash subscribed capital of almost exactly £1,000,000,000, which brought in a gross revenue of almost £100,000,000. Thus the figures of the combined revenue account for that year present themselves at once as percentages of the whole.

The expenses were as follow in thousands of pounds:

Maintenance of way and works	9,540
Locomotive power (including stationary engines)	19,288
Repair and renewal of carriages and waggons	5,173
Traffic expenses (coaching and merchandise)	19,348
General charges	2,459
Rates and taxes	3,757
Government passenger duty	330
Compensation to employees	146
Compensation for personal injuries, etc. ..	192
Compensation for damage and loss of goods	517
Legal and parliamentary expenses	306
Steamboat, canal, and harbour expenses ..	3,031
Miscellaneous working expenditure	648
Total working expenses	64,735

These heads of expenditure are those prescribed by law for this country, and require some rearrangement before they can be turned to account for our present purpose. In the words of a well-known authority: "Rates and taxes and government duty we may best strike out altogether. They represent not so much an actual expenditure as a deduction from income. Compensation ought to come in where it belongs. Compensation to an injured platelayer is properly part of the 'maintenance of way' expenditure; to an engine driver is part of 'locomotive power,' and so on. Parliamentary expenditure, if incurred in the promotion of a new line, is properly part of the capital cost of that line. If incurred in opposing a scheme believed to be contrary to the company's interest, it is a 'general charge'; or, in other words, is included in expenditure incurred, not in any special department of work, but for the [illegible] as a whole. Similarly, legal expenses should go where they belong. Fighting a claim for compensation for damage to goods is a necessary part of the cost of carrying goods; prosecuting for trespass on the line belongs to the expense of 'maintenance of way'; as would also litigation with, or drawing a contract with, a builder for station repairs, and so forth."

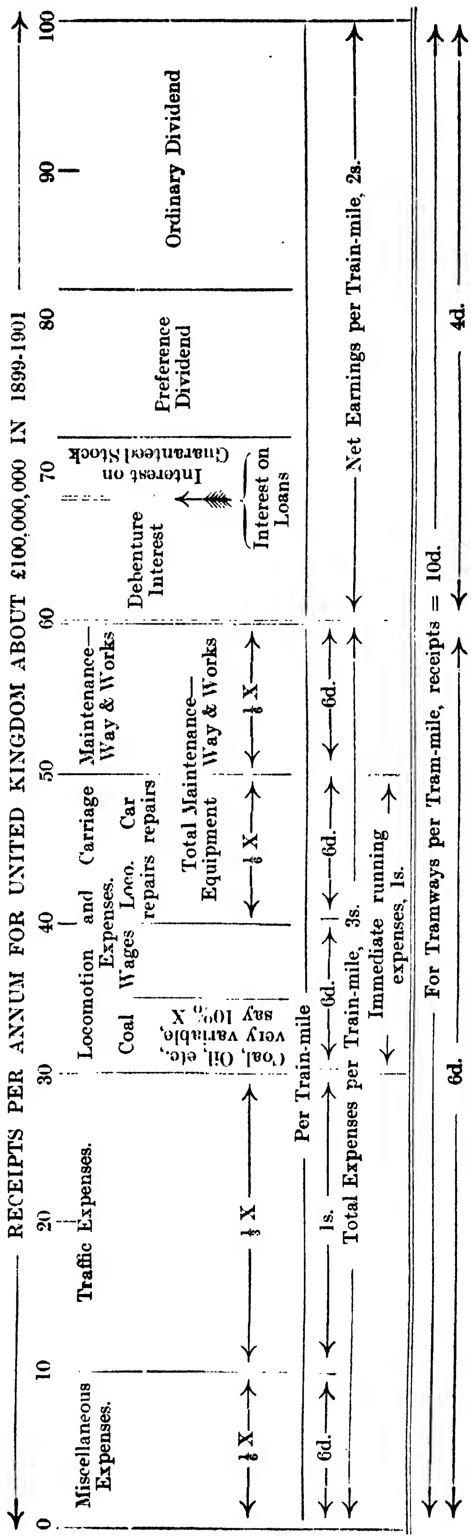
Maintenance Departments. The destination of the whole revenue of a railway company may be described as maintenance of one sort or another and grouped under four heads.

Maintenance of Physical State will comprise maintenance of the rails, fastenings, sleepers, ballast, earth work, bridges, culverts, fences, stations, signals, locomotives, carriages, waggons, etc.

Maintenance of Traffic will comprise the cost of running the trains, coal, wages of engine drivers, stokers, guards, porters, stationmasters, watchmen, signalmen, inspectors; cost of lighting, cleaning, stationery, etc.

Maintenance of the Organism will include the cost of co-ordinating the actions of the whole, and consist chiefly of expenses incurred at the head office.

Thus, all the working expenses can be distributed under these three heads, while the net earnings, which, together with these, account for



the whole revenue, are devoted to the maintenance of the proprietors, who, after paying the interest on the debts of the undertaking, have

railway cannot

its proprietors, its proprietors will cease adequately to maintain the railway. In the scheme on the preceding page, the expenses and earnings of an English railway have been separated out and divided into aliquot parts of the whole. This gives an arrangement of figures easily understood and remembered, as well as one that closely corresponds to average conditions, the adjustments needed to divide the expenses into equal divisions being very much smaller than the deviations found in actual working.

Facts for the Constructor. The business of the builder of railroads is chiefly concerned with those items of expense included under the headings, "Maintenance of way and works," and "Locomotive, carriage, and waggon expenses." The object of a railway is to reduce the cost of transportation. A heavy capital expenditure is incurred for this purpose. A railway is so efficient a means of doing this, that when originally introduced almost any construction might be a commercial success. In these days, however, the constructor must do his utmost to ensure that such work is done, and in such a way, as to reduce the cost of transportation in working to the lowest amount possible, having regard to the kind of traffic to be dealt with and the amount of the capital expenditure required to so reduce it.

The scheme presents also the items of expenditure in amounts *per train-mile*. The meaning of this is that the amounts in every case have been divided by the number of miles that have been traversed by the trains run during the period with which the accounts of expenditure deal. The object of presenting the items of expenditure in this form is to afford a convenient means by which the cost of working on different railways can be compared with one another.

Running Expenses. It will be seen that the actual cost of running a train one mile is approximately 1s., this being the average amount of the expenditure upon oil, fuel, wages of employees on the train, repairs to locomotive and vehicles. The cost of dealing with the train-load at each end of its journey appears as *traffic expenses*, and amounts also to an average of approximately 1s. The wear and tear to the railway itself and the works—*i.e.*, buildings, etc.—that belong to it comes to about 6d. per train-mile. Adding to this the amount required to keep in repair and renew when necessary the vehicles and locomotive of the train itself, we have once more 1s. on the average devoted to maintaining the whole plant of the organism in efficient physical condition.

Physical Maintenance. The cost of maintaining the railway, buildings, and plant is obviously in a different category to that of running trains and attending to traffic, of which the remaining expenses of a railway chiefly consist. The latter will depend upon competition and public demand to a much greater extent than the former.

Quickness in despatching parcels and goods, punctuality in trains of all kinds, comfort in passenger carriages, convenience at stations, are costly means of attracting traffic, but will not affect the item now under consideration. The cost that is incurred under it will, on the other hand, depend to a very great extent upon the solidity and workmanship of the structures, on their appropriateness to the purposes they were intended to fulfil, and the skill with which they were designed.

The Minimum Conditions. Before passing to the study of construction in detail, it may be well to point out the least conditions that must be fulfilled before railway construction of any kind is justified.

The expenses of keeping a railway of the lightest description in proper repair and its equipment in a state of working efficiency will amount at least to the average wages of one man for every mile of way open. The other expenses of dealing with traffic are not likely to be reduced to less than one-third of the receipts. The minimum value of X is not, therefore, likely to be reducible to less than $w + \frac{R}{3}$ when w is the average wages of an employé. Hence, if the estimated value of R is not greater than $w + \frac{R}{3}$ by an amount sufficient to pay adequate interest on the capital required to build and equip the railway, the conditions will not suffice to justify construction at all, a railway is too ambitious a scheme, and humbler means of transportation must be adopted.

In Great Britain the minimum conditions are reached when the estimated receipts are no more than £1 per day or £360 a year per mile of line open to traffic. If the average wages of employees per head be as small as 25s. or £65 per annum, the total expenses might be brought down to $65 + \frac{360}{3} = £175$, which, deducted from £360, leaves £185 as net earnings, thus enabling, at 4 per cent., a capitalisation of £4,625 per mile, which is less than that of any light railway in this country would be unless built in very favourable circumstances.

Continued

SPANISH—ITALIAN—FRENCH—GERMAN

Spanish by Amalia de Alberti; Italian by F. de Feo; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

SPANISH

Continued from page 2919

By Amalia de Alberti

Possessive Adjectives and Pronouns. Possessives follow the rule of adjectives ending in *o*. They agree with the thing possessed, not with the person or thing possessing. They may be classed as possessive adjectives, and possessive pronouns.

POSSESSIVE ADJECTIVES.

These directly precede or directly follow the noun. They are as follow:

Masculine.		*Feminine.*		
Singular.	*Plural.*	*Singular.*	*Plural.*	
mio	*mios*	*mia*	*mias*	my
tuyo	*tuyos*	*tuya*	*tuyas*	thy
suyo	*suyos*	*suya*	*suyas*	his, her, its, yours
nuestro	*nuestros*	*nuestra*	*nuestras*	our
vuestro	*vuestros*	*vuestra*	*vuestras*	your
suyo	*suyos*	*suya*	*suyas*	their, your

1. When *mio, tuyo*, and *suyo* precede the noun they lose their last syllable, and are the same for both genders, *viz.:*

mi	plural	*mis*
tu	,,	*tus*
su	,,	*sus*

2 The possessive adjective precedes the noun when no particular stress is intended. Examples: *mi padre*, my father; *mi madre*, my mother; *nuestra casa*, our house; *sus tierras*, their lands.

3. As *su, sus* may mean either his, her, its, or their, the appropriate pronoun is added when there is any possibility of mistake: *su vida de él*, his life; *su vida de ella*, her life; *sus vidas de ellas*, their lives (f.).

4. Politeness demands this construction with *Vd*, even when there is no ambiguity: *su vida de Vd*, your life; *sus vidas de Vds*, your lives.

5. *Vuestra* is used when the form of address is the formal *vos*, to one person, or the familiar *vosotros* to several. Examples: *Puedo imaginarme vuestra alegria á todas*, I can imagine how pleased you all were; *Rogamos á Vuestra Majestad*, We beseech your Majesty.

6. The possessive adjective follows the noun in direct address (vocative case): *Padre Nuestro*, Our Father; *amigo mio*, my friend.

7. The possessive adjective follows an impersonal noun preceded by a definite article, for greater effect in poetry or oratory: *el alma tuya*, thy soul; *la muerte mia*, my death.

8. With an adjective, the possessive adjective precedes or follows the noun according to the intensity of the meaning; for instance, *Mi querido amigo*, My dear friend, would be appropriate as the opening of an ordinary letter; *Querido amigo mio* denotes more affection and familiarity, while *Amigo mio querido* might serve for the opening of a love-letter.

9. In phrases such as "a friend of mine," "neighbours of ours," the possessive adjective follows the noun: *un amigo mio, unos vecinos nuestros.*

10. The personal pronoun in the dative must be used with the verb and the definite article with the noun, instead of the possessive adjective, when referring to parts of the body or articles of dress: *Se quitó el traje*, She took off her dress; *Me duele la cabeza*, My head aches.

POSSESSIVE PRONOUNS.

These are accompanied by the articles which agree with them; they are as follow:

Masculine.		
Singular	*Plural.*	
el mio	*los mios*	mine
el tuyo	*los tuyos*	thine
el suyo	*los suyos*	his, hers, its, yours
el nuestro	*los nuestros*	ours
el vuestro	*los vuestros*	yours
el suyo	*los suyos*	theirs, yours
Feminine		
Singular.	*Plural.*	
la mia	*las mias*	mine
la tuya	*las tuyas*	thine
la suya	*las suyas*	his, hers, its, yours
la nuestra	*las nuestras*	ours
la vuestra	*las vuestras*	yours
la suya	*las suyas*	theirs, yours

1. The neuter possessive is the same as the masculine singular with the article *lo, lo mio*, etc.; it has no plural.

2. Possessive pronouns lose their article when they stand as predicate of the verb to be. Example: *Esos guantes son mios*, Those gloves are mine.

3. But if particular emphasis is intended, they retain the article. Example: *Esos guantes son los mios*, *Those* gloves are *mine.*

Demonstrative Pronouns. There are three demonstrative pronouns which agree with the noun in gender and number, except the neuter forms, which are invariable:

Singular.			
Masculine.	*Feminine.*	*Neuter.*	
este	*esta*	*esto*	this
ese	*esa*	*eso*	that
aquel	*aquella*	*aquello*	that

	Plural.	
Masculine.	*Feminine.*	
estos	*estas*	these
esos	*esas*	those
aquellos	*aquellas*	those

1. *Este* generally means something near the speaker, *ese* something near the person addressed, and *aquel* something at a distance from both.

2. The demonstrative pronoun regularly precedes the noun: *esta iglesia*, this church; *esa ciudad*, that city.

3. It follows the noun, which is preceded by a definite article in such sentences as the following, when the meaning may often be intensified in English by the addition of *here*: *los buenos amigos esos*, these good friends (here); *el hombre ese*, that man (there).

4. The definite article is also used as a demonstrative pronoun to signify *that*; it can often be rendered by the English possessive case. Example: *mi perro y el de mi hermano*, my dog and that of my brother (or my brother's); *nuestra casa y la de Vd*, our house and yours (literally, *that of you*).

5. The neuter forms *esto*, etc., can never be used with a substantive; they have a thought, phrase, etc., for their antecedent. *Esto*, something said by the speaker; *eso*, something said by the person spoken to; and *aquello*, something referred to by either. Example: *esto es lo que me han dicho*, this is what I have been told; *eso no me importa*, I do not care for that; *aquello no fué verdad*, that was not true.

6. Este used substantively refers to the last-mentioned of two persons or things, and *aquel* to the first; *este* and its variations may, therefore, be translated "the latter," and *aquel* and its variations "the former." *Este*, *ese*, and *aquel* are also used substantively as *this*, *this one*, *that one*, etc. Examples: *¿quién es éste?* who is this (man); *el marido de ésta, y el padre de aquel*, the husband of this (woman) and the father of that (man).

7. The masculine and feminine demonstratives take an accent when used emphatically.

Vocabulary	**Vocabulario**
What is the weather?	Qué tiempo hace?
It is cold	Hace frio
It is warm	Hace calor
It is mild	Está templado
It is snowing	Está nevando
It is freezing	Está helando
It is raining	Está lloviendo
The wind blows	Sopla el viento
North wind	Viento norte
The east wind	El levante
Contrary wind	Viento contrario
Trade winds	Vientos generales
Land breeze	Viento terral
A storm	Una tempestad
A shower	Un aguacero
Lightning	Relámpagos
Thunder	Truenos
A thunderbolt	Un rayo
An eclipse of the sun	Un eclipse de sol
An eclipse of the moon	Un eclipse de luna
A meteor	Un metéoro
Fireworks	Fuegos artificiales
A sky rocket	Un cohete
An aurora borealis	Una aurora boreal
The clouds	Las nubes
A cloudy sky	Un cielo nublado
The waves	Las ólas
The rocks	Las rocas
The lifeboat	El bote salvavidas
The lifebelt	El salvavidas
To swim	Nadar
A school of swimming	Una escuela de natacion
A bath	Un baño
Sea baths	Baños de mar
Medicinal baths	Baños medicinales
Vapour baths	Baños de vapor
A douche	Una ducha
Salt water	Agua salada
Fresh water	Agua dulce
Sea water	Agua del mar
Sulphur water	Agua sulfurosa
The beach	La playa
A sandy beach	Una playa arenosa
Shells	Las conchas
A stone	Una piedra
A whetstone	Piedra de amolar
Touchstone	Piedra de toque
A magnet	Piedra imán
Pumice stone	Piedra pomez
Caustic	Piedra infernal

EXERCISE VIII. (1).

Translate the following into Spanish:

1. That overcoat is mine, and that dress is
. . . .
yours. 2. These flowers are mine, these books
. . . .
are thine. 3. I saved my life with a lifebelt.
. . . . salvé . . . .
4. Thy hands are clean. Her face is pretty.
. . . . limpias. . . . .
5. Your life is laborious. 6. God keep your
. . . . trabajosa. . . . . . guarde . .
Majesty 7. My friend, it is snowing; one
. . . .
cannot go out. 8. My dear friend, I do
. . . .
not fear the snow. 9. Some neighbours of
. . . temo . . . .
ours have been killed by a thunderbolt. 10.
. . . .
That child is ill. 11. A sky rocket fell on that
. . . . enfermo . . . . . . cayó . . . . .
woman. 12. Those clouds darken the sky. 13.
. . . . oscurecen . . . .
That is sea water. 14. That man killed his
. . . . mató . . .
brother—that is what they have told me; I do
. . . .
not believe it.
. . . .

EXERCISE VIII. (2).

Translate the following into English:

1. No me importa lo que han dicho.
2. Aquello que han dicho no es verdad.
3. Eso es mio, es mi sombrero, y mi libro.
4. Esos hombres son buenos.

5. Mi perro está en casa con aquel hombre.
6. Esta casa y esta iglesia son mías.
7. Esto es malo, y aquello es bueno.

1. El amor no se oculta.
2. Vd está enamorado de la hija de su vecino.
3. Si, señor, y se lo dije ayer.
4. Vd le es indiferente. No lo creo.
5. No tenga impaciencia; la paciencia es una virtud.
6. Una persona que odia busca venganza.
7. Esos son malos sentimientos, tenga bondad, y perdone.
8. El capitan, además de ser marino, es escritor.
9. El doctor de quien le hablé es un especialista, pero no es un oculista.

10. Le han robado sus instrumentos de cirugía.
11. No tiene dolor de muelas, porque sus

un diario muy bien escrito.

KEY TO EXERCISE VII. (2).

1. He spoke to him, and he did not listen.
2. Give him the bread; I have given it to him.
3. Do you know this woman? I know her
4. It is not true; I do not believe it.
5. He has hurt himself; call the doctor.
6. They have gone; call them.
7. It seems to me that he hates that man.
8. He met them in your house, and they fought.

Continued

ITALIAN

Continued from page 2922

By Francesco de Feo

Degrees of Comparison. The qualifying adjective may be of three degrees: positive (*buono*, good), comparative (*migliore*, better), superlative (*ottimo*, best). The student will observe that the adjective given as an example is irregular in Italian as it is in English.

COMPARATIVE DEGREE. The comparative degree may be of three sorts: of equality, superiority, and inferiority.

1. The RELATION OF EQUALITY is expressed in Italian by:

così . . . come, or *tanto . . . quanto*, as . . . as, so . . . . as; *anto, -a . . . . quanto, -a*, as much . . . as, so much . . . as; *tanti, -e . . . quanti, -e*, as many . . . as, so many . . . as.

Questa stanza è così grande come quella, This room is as large as that.

Noi abbiamo scritto tante lèttere quante voi, ma voi non avete scritto tanto quanto noi, We have written as many letters as you, but you have not written so much as we.

NOTE. In the forms *così . . . come, tanto . . . quanto, così* and *tanto* are generally omitted, so that the above examples may be written: *Questa stanza è grande come quella. Noi abbiamo scritto tante lèttere quante voi, ma voi non avete scritto quanto noi.*

2. The RELATION OF SUPERIORITY is expressed by:

più . . . di, or *più . . . che*, more . . . than.

Il ferro è più ùtile dell' oro, Iron is more useful than gold.

Quell' uomo è più morto che vivo, That man is more dead than alive.

Meglio tardi che mai, Better late than never.

3. The RELATION OF INFERIORITY is expressed by:

meno . . . di, or *meno . . . che*, less . . . than.

Noi siamo meno ricchi di voi, We are less rich than you.

Quella signora è meno bella di questa, That lady is less beautiful than this.

Più . . . che and *meno . . . che* are used when the second of the two terms of comparison is an adjective, or a verb or an adverb. In many cases *più . . . di, meno . . . di*, and *più . . . che, meno . . . che* are equally correct.

The preposition *di* is coupled with the article according to the rules already given—*e.g.*:

Mio padre è più vecchio di vostro padre, My father is older than your father. In this sentence *di* must be used and not the compound article *del*, because the possessive *vostro* precedes the noun *padre*. [See the Possessive Adjectives, page 2771.]

Questo libro è più utile di quello, This book is more useful than that. In this sentence *del* would be incorrect, because *quello* is never preceded by the article. [See Demonstrative Adjectives, page 2632.]

Il nostro giardino è più grande del loro, Our garden is larger than theirs; here *del* must be used and not *di*, because *loro* always requires the article. [See the Possessive Adjectives.]

The comparison of superiority and inferiority may be strengthened by adding *molto, assai*, etc.. to *più* and *meno*—*e.g.*:

Mio fratello è molto più diligente di mio cugino, My brother is much more diligent than my cousin.

La vostra casa è molto meno còmoda della nostra, Your house is much less convenient than ours.

NOTE. The second of the two terms of the comparison of superiority and inferiority is often understood, as:

La vostra casa è grande, ma la nostra è molto più grande (della vostra), Your house is large, but ours is much larger (than yours).

Non ho mai visto un uomo più impudente (di Pietro), I never saw a man more impudent (than Peter).

Quanto più . . . tanto più, or *più . . . più* = the more . . . the more.

Quanto meno . . . tanto meno, or *meno . . . meno* = the less . . . . the less—*e.g.*: *Quanto più leggiamo, tanto più impariamo*, or *più leggiamo, più impariamo*, The more we read, the more we learn.

EXERCISE XVII.

fare (*fàhreh*), to make, to do
fa (*fah*), it makes, it does
faceva (*fahchèhvah*), it made
farà (*fah-ràh*), it will make
fa freddo, it is cold
fa caldo, it is hot
fa vento, it is windy
passeggiata (*pahsseh-dgeeàhtah*), walk
fare una passeggiata, to take a walk
andare (*ahn-dàh-reh*), to go
fedele (*feh-dèh-leh*), faithful
ieri (*ee-èh-ree*), yesterday
oggi (*òdgee*), to-day
domani (*domàh-nee*), to-morrow,

1. Pietro è buono come Carlo. 2. Io ho danaro quanto voi. 3. Mio padre è più ricco del vostro amico. 4. Quell' orològio è più caro di quella catena. 5. Il cane è più fedele del gatto. 6. L'inverno è molto più freddo dell' autunno, e la primavera è molto meno calda dell' estate. 7. Queste case sono più alte che larghe. 8. Ieri faceva freddo, ma oggi fa molto più freddo. 9. Se domani farà più caldo, andremo tutti a fare una passeggiata in campagna. 10. Questa strada è troppo lunga, l'altra è molto più corta.

SUPERLATIVE DEGREE. To indicate the highest degree of a quality the terminations *-issimo*, *-a*, *-i*, *-e*, are added to the last consonant of the adjective, as: *caldo*, *caldìssimo*, hot, hottest; *puro*, *purìssimo*, pure, purest.

The adjectives in *co* and *go* add the terminations *-issimo*, *-a*, *-i*, *-e* to the last consonant of their plural, as: *poco*, *pochìssimo*, little, very little; *ricco*, *ricchìssimo*, rich, very rich; *cattòlico*, *cattolicìssimo*, catholic, very catholic.

The adjectives ending in *io* drop both vowels before the terminations *-issimo*, *-a*, *-i*, *-e*; but if the *i* is accented, only the *o* is dropped, as: *sàvio*, *savìssimo*, wise, wisest; *pìo*, *piìssimo*, pious, most pious.

NOTE. The Latin forms of some adjectives ending in *ico*—as: magnifico, *magnificentìssimo*; benefico, *beneficentìssimo*, etc.—are only used rhetorically. Some adjectives ending in *re*, *ro* retain in the superlative the Latin form in *èrrimo*—*e.g.*, *cèlebre* (*chèh-leh-breh*), famous, *celebèrrimo*; *mìsero* (*meèseh-ro*), miserable, *misèrrimo*; *salubre*, healthy, *salubèrrimo*.

1. The ABSOLUTE SUPERLATIVE may also be formed by placing an adverb before the positive, as: *molto caldo*, very hot; *assai bella*, very beautiful; *estremamente buono*, extremely good; etc.

The superlative of some adjectives is also formed by placing *-arci* or *-stra* before the positive, as: *milionàrio*, millionaire, *àrcimilionàrio*; *grande*, large, *stragrande*.

Another way of forming the superlative is to reduplicate the adjective, as: *lungo lungo*, very long; *corto corto*, very short; etc.

2. The RELATIVE SUPERLATIVE is formed by placing the article before the comparative degree of the adjective.

The relative superlative may be of superiority, and is then expressed by *il più*, *la più*, *i più*, *le più*, the most; or of inferiority, and is expressed by *il meno*, *la meno*, *i meno*, *le meno*, the least—*e.g.*, *Pietro è il più diligente scolaro della scuola*, Peter is the most diligent pupil of the school; *Carlo è il meno ricco di tutti*, Charles is the least rich of all.

If the adjective comes after the noun preceded by the article, it is better not to repeat the article: *lo scolaro* (*il*) *più diligente*. But the article is necessary before *più* and *meno* if the noun is preceded by the indefinite article, as: *un uomo il più cattivo*.

The following adjectives, besides the regular, have also a comparative and superlative of Latin form:

alto, high; *superiore*, superior; *supremo* or *sommo*, supreme, very high.

basso, low; *inferiore*, inferior, lower; *ìnfimo*, the lowest.

buono, good; *migliore*, better; *òttimo*, the best.

cattivo, bad; *peggiore*, worse; *pèssimo*, the worst.

grande, great; *maggiore*, greater; *màssimo*, the greatest.

píccolo, little; *minore*, less; *mìnimo*, the least.

Pronounce: *àhl-to*, *soopeh-reeò-reh*, *sooprèhmo*; *bàhsso*, *eenfeh-reeò-reh*, *eèn-feemo*; *boo-òno*, *mee-leeò-reh*, *òtteemo*; *cah-tteè-vo*, *peh-dgeeò-reh*, *pèhsseemo*; *gràhn-deh*, *mah-dgeeò-reh*, *màhsseemo*; *peèccolo*, *meenò-reh*, *meèneemo*.

For *migliore*, *peggiore*, and *minore* in familiar language may be also used the adverbial forms *meglio*, *peggio*, *meno*: *Le peggio cose* for *le cose peggiori*, the worst things.

Il maggiore, *il minore*, etc., mean also the elder, the eldest, the younger, the youngest; *il fratello maggiore*, *la sorella minore*.

In familiar language a few substantives may also assume a comparative and superlative, as: *più asino*, *asinìssimo*, *servitorìssimo*, *padronìssimo*.

EXERCISE XVIII.

mùsica (*moòseecah*), music
pàgina (*pàh-dgeenah*), page
stòria (*stòreeah*), history
spesso (*spèhsso*), often
speso (*spèhso*), spent
ferro (*fèhrro*), iron
acciàio (*ah-chee-àheeo*), steel
soddisfatto (*di*), satisfied (with)
studiato (*stoodee-àhto*), studied
rimèdio (*reemèh-deeo*), remedy
male (*màhleh*), evil
tanto mèglio, so much the better
tanto pèggio, so much the worse
vi piace? (*vee pee-àhcheh*), do you like?
mi (*mee*) *piàce*, I like
è meglio, it is better

1. Questa mùsica è bellìssima. 2. Dante è il più grande poeta d'Italia. 3. Questa è la più bella pàgina della nostra stòria. 4. Il più grande dèbito è un benefìcio ricevuto. 5. I pòveri sono spesso più felici dei ricchi. 6. Se avete speso tutto il vostro danaro, tanto pèggio per voi. 7. L'acciàio è più duro del ferro. 8. Noi siamo molto soddisfatti dei nostri studi. 9. I ragazzi hanno studiato tutto il giorno. 10.

Tanto meglio, più stùdiano, più impàrano. 11. È meglio non parlare di certe cose. 12. Quella ragazza è bellìssima ; ha gli occhi neri neri e i capelli biondi come l' oro. 13. Mio fratello minore è in collègio ; egli è un ragazzo intelligentìssimo ; è il migliore di tutti gli scolari. 14. Vi piace il mio vestito nuovo ? 15. Non mi piace tanto, è troppo chiaro ; il mio è molto più scuro. 16. Io àbito (I live) molto lontano, ma il nostro amico àbita molto più lontano. 17. Spesso il rimèdio è peggiòr del male.

KEY TO EXERCISE XVI.

1. Fifty francs. 2. Fifty-one horses. 3. Here is the laundress's list: shirts twenty-one, collars forty-one, handkerchiefs eleven. 4. A pound sterling is five and twenty francs. 5. At Marathon ten thousand Greeks under the command of Miltiades defeated a hundred thousand Persians. 6. In the last battle our enemies lost three thousand men. 7. We are at home on Wednesday and Friday. 8. The months of January, March, May, July, August, October, December have thirty-one days, February has twenty-eight, the others thirty. 9. The year has four seasons: Spring, Summer, Autumn, Winter. 10. Tarquinius Superbus was the seventh and last King of Rome. 11. At present my son has only two thousand francs a year, but in two or three years he will have almost (the) double. 12. Louis the XVI was beheaded in January, 1793. 13. It is half past eight and the train starts at five minutes past nine.

Continued

FRENCH Continued from page [illegible]

By Louis A. Barbé, B.A.

III. From the PAST PARTICIPLE are formed all the COMPOUND TENSES by adding it to the respective tenses of the auxiliary *avoir* or *être*.

DONNÉ	FINI
j'ai donné	*j'avais fini*
REÇU	VENDU
j'aurai reçu	*que j'aie vendu*

IV. From the PRESENT INDICATIVE the IMPERATIVE is formed by omitting the personal pronouns. In the first conjugation the final *s* of the second person singular is dropped. The imperative has no third persons of its own, but borrows those of the subjunctive:

INDICATIVE.	IMPERATIVE.
1. *tu donnes*	*donne*
nous donnons	*donnons*
vous donnez	*donnez*
2. *tu finis*	*finis*
nous finissons	*finissons*
vous finissez	*finissez*
3. *tu reçois*	*reçois*
nous recevons	*recevons*
vous recevez	*recevez*
4. *tu vends*	*vends*
nous vendons	*vendons*
vous vendez	*vendez*

Exceptions:

1. Third Conjugation:

INDICATIVE.	IMPERATIVE.
AVOIR	
tu as, thou hast	*aie*
nous avons	*ayons*
vous avez	*ayez*
SAVOIR	
tu sais, thou knowest	*sache*
nous savons	*sachons*
vous savez	*sachez*

2. Fourth Conjugation:

INDICATIVE.	IMPERATIVE.
ÊTRE	
tu es, thou art	*sois*
nous sommes	*soyons*
vous êtes	*soyez*

V. From the PAST DEFINITE the IMPERFECT SUBJUNCTIVE is formed, by changing *s* of the second person singular into *sse, sses, t, ssions, ssiez, ssent.* In the third person singular, the vowel immediately preceding the final *t* takes a circumflex accent:

tu DONNA-S	*tu* FINI-S
que je donna-sse	*que je fini-sse*
que tu donna-sses	*que tu fini-sses*
qu'il donnâ-t	*qu'il finî-t*
que nous donna-ssions	*que nous fini-ssions*
que vous donna-ssiez	*que vous fini-ssiez*
qu'ils donna-ssent	*qu'ils fini-ssent*
tu REÇU-S	*tu* VENDI-S
que je reçu-sse	*que je vendi-sse*
que tu reçu-sses	*que tu vendi-sses*
[illegible]	*qu'il vendî-t*
que nous reçu-ssions	*que nous vendi-ssions*
que vous reçu-ssiez	*que vous vendi-ssiez*
qu'ils reçu-ssent	*qu'ils vendi-ssent*

1. **Special Remarks.** All prepositions but one require the verb which follows them to be in the infinitive. The single exception is *en* (in) which takes the present participle after it:

Il joue au lieu de travailler, He plays instead of working ; *Il me regarda sans rien dire,* He looked at me without saying anything ; *Après avoir lu la lettre il me la donna,* After having read the letter he gave it to me ; *Les ouvriers travaillaient en chantant,* The workmen sang as they worked ; *Elle nous regarda en souriant,* She looked at us smiling.

2. In English, "one," "ones" frequently take the place of a noun after an adjective. In French, there is no such construction, and the adjective alone must be used :

There are two books on the table, a large one and a small one, *Il y a deux livres sur la table, un petit et un grand ;* Take the good ones and leave the bad ones, *Prenez les bons et laissez les mauvais.*

3. An adverb must never be placed between subject and verb. Its usual place is after the verb in a simple tense, and between the auxiliary and the verb in a compound tense :

I never see him, *Je ne le vois jamais ;* He has never spoken to me, *Il ne m'a jamais parlé.*

4. An "if" clause must have its verb in either the present or the imperfect indicative.

With an "if" clause in the present, the "result" clause must be either in the present or the future indicative, or in the present imperative. With an "if" clause in the imperfect, the "result" clause must be in the conditional:

S'il est ici, il doit nous voir, If he is here, he must see us; *S'il est ici, il nous verra,* If he is here, he will see us; *S'il vient demain, nous le verrons,* If he comes to-morrow, we shall see him; *S'il est ici, qu'il vienne nous parler,* If he is here, let him come and speak to us; *S'il était ici, il viendrait nous parler,* If he were here, he would come and speak to us.

5. *Assez,* enough, always precedes the adjectives which it modifies:

Le plus petit ennemi est toujours assez grand pour être dangereux, The smallest enemy is always big enough to be dangerous.

Exercise XXIII.

Vocabulary

le bout, end, tip
la cause, cause
le charançon, weevil
le chef-d'œuvre, masterpiece
la chenille, caterpillar
la chose, thing
le commencement, beginning
la contrariété, vexation
le crime, crime
le défaut, defect
la dent, tooth
envie (f), envy
éléphant (m.), elephant
enfant (m.), child
ennemi (m.), enemy
ennui (m.), annoyance
la famille, family
la fluxion de poitrine, inflammation of the lungs
la haine, hatred
importance (f.), importance
insecte (m.), insect
la jalousie, jealousy
le laboureur, husbandman
le mal, ailment
la maladie, illness
le mensonge, falsehood
la moisson, harvest
la mouche, fly
le nez, nose
le panier, basket
la perte, loss
le point, spot, speck
la postérité, posterity
la progéniture, progeny
le rhume, cold
la ruine, ruin
la sauterelle, grasshopper, locust
la ténuité, tenuity, minuteness
le tour, turn
la treille, vine-stalk
la vanité, vanity
la verrue, wart
le vice, vice
le voisinage, neighbourhood
le voisin, the neighbour
le voleur, thief

continuel, continual
dangereux, dangerous
durable, lasting
imperceptible, imperceptible
implacable, implacable
indifférent, indifferent, of no consequence
indulgent, indulgent
innocent, innocent
insupportable, unbearable
mortel, deadly
permanent, permanent
petit, little, slight
pourri, rotten, bad (of fruit)
seul, alone, only
vilain, ugly, nasty

arriver, to arrive, come
causer, to cause
coûter, to cost
craindre, to fear
dépouiller, to despoil, plunder
gâter, to spoil, decay (of teeth)
mépriser, to despise
négliger, to neglect
réformer, to reform, cure

à cause de, because of
assez, enough
aujourd'hui, to-day
bien, very
bien de (des), many
bientôt, soon
contre, against
d'ailleurs, moreover
demain, to-morrow
en herbe, in the blade
en outre, in addition
ensuite, afterwards, then
malheureusement, unfortunately
presque, almost
parmi, amongst
quand, when
quelquefois, sometimes
sans, without, but for
seulement, only
sur nos gardes, on our guard
toujours, always.

Translate into French.

Those who despise small defects are very wrong. The smallest enemy is always big enough to be dangerous. It is not elephants that cause the loss of harvests and the ruin of husbandmen; it is locusts and little caterpillars, when the corn is in the blade; weevils and other imperceptible insects, when it is ripe. It is not big robbers only that despoil the vine-stalk and the orchard of their fruit; it is little ones also, sparrows and even flies. Without being deadly, little ailments are sometimes enemies as unbearable as the big illnesses of which we are afraid. It is almost always through little neglected ailments that the serious (great) ones come. To-morrow the little cold of to-day will perhaps be inflammation of the lungs. But for little defects there would not be any vices. Moreover, a little defect is not a slight thing, and where there is one, there will never be any masterpiece. A wart is not very big, but if you have it on the tip of your nose, it will be for you a continual cause of annoyance and of vexation. A small defect is never of slight importance if it is permanent. What is lasting is never slight. Moreover, a little defect is always the beginning of a big one; vices themselves are the children of little defects. The little defect will soon be great; where there was one there will soon be several. A little defect is never alone. It always has a family. If it is not for itself, it is for its posterity that it is to be feared. You have a tooth that has a little black spot. It is nothing; but, if you neglect it, it will soon be the whole tooth that will be decayed. After that one it will be the neighbour (f.), and then the neighbour's neighbour, and the little black speck that you have neglected will have cost you several teeth. If there is a bad plum in a basket of plums, all the plums will soon be bad. The neighbourhood of a little defect is never of no consequence. Vanity seems to be a slight defect; but it is a slight defect that has a very nasty progeny. It has for (its) son, falsehood, which, unfortunately, is not its only child. It has, in addition, two daughters, who are jealousy and envy. Amongst their posterity they will have hatred, which will, in (à) its turn, be the mother of many crimes. It is because of their very minuteness that little defects are so dangerous. If they did not look so innocent we should be afraid of them, we should be on our guard against them. Be indulgent towards (à) the little defects of your friends, if you are not in a position to cure them; but towards yours, which are always under your hand, be implacable.

KEY TO EXERCISE XXII.

1. A qui sont ces livres ? Ils sont à mon frère.

2. J'avais besoin de parler à votre père, mais il n'y était pas.

3. L'âne est sobre et patient ; il serait le plus beau des animaux domestiques s'il n'y avait point de cheval.

4. Les Gaulois étaient braves et robustes.

5. Le Maréchal Lannes avait été teinturier ; le Maréchal Ney fut tonnelier avant d'être soldat.

6. Le père du philosophe Diderot et celui de l'historien Rollin étaient couteliers.

7. Le pardon vaut mieux que la vengeance.

8. Les Romains ont été les maîtres du monde.

9. Il y avait une fois deux hommes qui étaient bien pauvres et bien malheureux.

10. Le premier était aveugle de naissance ; le second était paralysé.

11. Ils étaient l'un et l'autre (tous deux) incapables de rien faire.

12. L'aveugle, qui était robuste, porta le paralytique.

13. Le paralytique qui était doué d'une bonne vue dirigea son compagnon.

14. Seuls ils seraient morts de faim.

15. Unis ils furent à même de gagner leur vie.

Continued

GERMAN Continued from page 1928

By P. G. Konody and Dr. Osten

LV. Comparison of Adjectives. As in English, the comparison of superiority of quality, in monosyllabic and in many dissyllabic adjectives (also in participles and adverbs), is expressed by the addition of the suffixes -r or -er in the second degree or comparative, and -ſt or -eſt in the third degree or superlative. Examples: dreiſt, bold ; dreiſt-er, bolder : dreiſt-eſt, boldest. The *superlative* is either used attributively with the definite article (der, die, das dreiſt-eſte, the boldest), and with the inflections of gender and declension ; or predicatively, preceded by the dative preposition am (3) with the corresponding termination of the dative. Examples: (attributive) der breit-eſte Tiſch, the widest table: (predicative) der Tiſch iſt am (3) breit-eſten (dative), the table is the widest [among those compared].

1. In accordance with the rule of euphony the comparative adjectives and adverbs ending in -e have only -r added to the positive ; all others take -er. For the same reason adjectives ending in -el, -er, -en often cast off the -e- in the comparative : edel, noble, ed(e)l-er ; finſter, dark, finſt(e)r-er ; offen, open, off(e)n-er ; verlaſſen, dejected, verlaſſ(e)n-er ; but the -e- is retained in beſonnen, considerate, circumspect, beſonnen-er.

It must be remembered that the adjectives ending in -el, -er, -en, which cast off the -e- in the comparative, retain this vowel in the superlative : eitel, vain, eitler, but eitelſt ; heiter, merry, heitrer, heiterſt ; eben, even, level, ebner, ebenſt.

2. The *superlative* is formed by the addition of -eſt when the positive terminates in -d, -t, or in the hissing sounds -ß, -ſch, -z : rund, round, rund-eſt ; nackt, naked, nackt-eſt ; ſüß, sweet, ſüß-eſt ; morſch, brittle, morſch-eſt ; ſtolz, proud, ſtolz-eſt ; in all other cases it is formed by the addition of -ſt : fein, fine, delicate, fein-ſt ; langſam, slow, langſam-ſt. The superlative of groß, great, größ-eſt (with modification of the vowel) is generally used in the shortened form größt—attributively der, die, das größte, and predicatively am größten.

In the case of many adjectives—especially monosyllabics—the comparison is not only denoted by suffixes, but also by the modification of the vowel : klug, prudent, klüg-er, klüg-ſt ; jung, young, jüng-er, jüng-ſt ; lang, long, läng-er, läng-ſt. In compounds the same adjectives do *not* modify the vowel : weltklug, worldly-wise, weltklug-er, weltklug-ſt ; arm, poor, ärm-er, ärm-ſt ; but blutarm, anæmic (also miserably poor, poor as a church-mouse), blutarmer, blutarmſt ; warm, warm, wärmer, wärmſt ; but brühwarm, boiling hot, brühwarmer, brühwarmſt, etc.

In several adjectives both forms of comparison (with and without modified vowel) are employed alternatively : blaß, pale, bläſſer, bläſſeſt, or blaſſer, blaſſeſt ; geſund', healthy, geſünder, geſündeſt, or geſunder, geſundeſt ; but the comparative and superlative *without* modification of the vowel is generally preferable.

3. IRREGULAR COMPARISON. The comparison of the following adjectives is irregular :

1, hoch, high ; 2, höher ; 3, höchſt (the c is omitted in the comparative) ;

1, nahe, near ; 2, näher ; 3, nächſt (a c is added in the superlative) ;

1, gut, good ; 2, beſſer ; 3, beſt ;

1, viel, much ; 2, mehr ; 3, meiſt (the form „mehrſt" is scarcely used) ;

1, gering (wenig), insignificant, little ; 2, geringer, also minder, weniger ; 3, geringſt, mindeſt, wenigſt ;

1, früh (also ehe), early ; 2, früher, eher ; 3, früheſt, eheſt (also erſt).

4. The declension of the comparative and superlative follows the mode of declension of the positive.

5. The Comparison of Equality occurs when persons or objects whose qualities are compared are of equal standing. It is formed by the particle wie, like, as (denoting equality or similarity), preceded by the demonstrative particle ſo or ebenſo (as *or* just as), which is placed before the adjective. The adjective naturally stands in the positive : Ihre Augen waren ſo blau, wie der Himmel, her eyes were as blue as the sky ; mein Hund iſt ebenſo klug, wie der ſeinige, my dog is just as clever as his. After ebenſo the particle of superiority als, than, is also used, but wie is more correct.

6. In the Comparison of Superiority the conjunction als, than, is *always* used : er iſt fleißiger als ich, he is more diligent than I. The two conjunctions used with the comparison of equality and superiority, wie and als, are very frequently confounded, even by Germans themselves.

The comparison of superiority is often intensified by the addition of such words as viel, much; sehr viel, very much; bedeu'tend, un'gemein, um ein Bedeu'tendes, considerably: etwas, something, somewhat; weit, bei weitem, far, by far; wenig, ein wenig, a little; am meisten, mostly; allerwenigstens, least, etc.

For reasons of euphony the adjectives terminating in -er, when used attributively, often form the comparative with m e h r, more, etc.—for instance, the clumsy comparative of bitter: ein bitterer-er Geschmack, a bitterer taste, is replaced as in English by: ein mehr bitterer Geschmack, a more bitter taste; or by: ein Geschmack von größerer Bitterkeit (a taste of greater bitterness). For the same reason the clumsy superlative of adjectives ending in -isch is avoided by the use of sehr, very; äußerst, un'gemein, exceedingly; höchst, most, etc. Instead of the superlative of schmeich'lerisch, adulatory, cajoling—der schmeichlerisch-este; or of phanta'stisch—der phantastisch-este, it is better to use the circumlocution: der sehr (ungemein, höchst, äußerst) schmeichlerische, phantastische.

LVI. Numerals [see XXXII.]. The *Ordinal Numerals*, substantively or adjectively used with the definite, and sometimes with the indefinite article, are derived from the *Cardinal Numerals* [page 2050], and are formed by the suffix -te added to the numerals from 1 to 19, and -ste to all others. Exceptions to this rule are the ordinal numerals of 1, eins, 3, drei, and 8, acht, which are formed: der e r s t e, der d r i t t e, der a c h t e. Thus the ordinal numerals are:

der erste	der neunte	der siebzehnte
der zweite	der zehnte	der achtzehnte
der dritte	der elfte	der neunzehnte
der vierte	der zwölfte	der zwanzigste
der fünfte	der dreizehnte	der einund-zwanzigste
der sechste	der vierzehnte	
der siebente	der fünfzehnte	
der achte	der sechzehnte	etc.

The ordinal numbers added to the names of kings, etc., are written in Roman figures without the article, as in English, but when pronounced the article must not be omitted: Die Frauen Heinrichs VIII. (the wives of Henry VIII.) is pronounced die Frauen Heinrichs des Achten.

The declension of the ordinal numerals follows that of the attributive adjective [see XXVI.]. They can be employed as such with the indefinite article and the case ending: der zehnte, the tenth, and ein z e h n t e r.

LVII. Derivatives of Numerals. From the cardinal numerals are derived:

1. The Distributive Numerals, by use of the adverb j e: je fünf, by fives; je zehn, by tens, ten of each. This form is also employed with ordinal numbers: je der erste, je der zehnte, implying the first, or the tenth, in each group. The distributive numerals are subject to declension.

2. Reiteratives are formed by the addition of the substantive -mal (times): ein-mal, zwei-mal, drei-mal, etc., once, twice, thrice, etc.; and also in connection with the indefinite numerals viel, much; manch, some; kein, none; einige, several, a few. Examples: viel-mal, many a time, often; manch-mal, sometimes, kein-mal, never; einige-male, several times; alle-mal, always; ein paar mal, a couple of times. When used as attributive adjectives, they are declined as such [see XXVI.]—*e.g.*: nach dreimalig-em Sturmlauf, after three assaults [thrice undertaken]; das einmalig-e Signal (weak, with the definite article), and einmalig-es Signal (strong, without article) genügte, one signal [the signal once given] sufficed. Mal is also applicable to ordinal numerals: zum ersten, zweiten, dritten male, etc., for the first, second, third time, etc.

3. Multiplicatives are formed by the addition of -fach, -fältig (or -faltig), -fold, indicative of multiplicity: zwei-fach, drei-fach, hundert-fach, hundert-fältig, etc., twofold, threefold, a hundredfold, etc.; also with indefinite numerals: vielfach, vielfältig, mannigfaltig, mannigfach, manyfold. They are used as adjectives and declined.

4. Variative Numerals are formed by the addition of the suffix -erlei, which indicates variety, kind, etc.: ein-erlei, zwei-erlei, of one sort, of two sorts; and with indefinite numerals: viel-erlei, manch-erlei, mehr-erlei, all without declension and employed adverbially.

5. Distinctives are derived from the ordinal numerals by the suffix -ns or -ens (-ly): erstens, zweitens, drittens, firstly, secondly, thirdly, etc.

6. Fractional Numerals are formed by the suffix -tel, an abbreviation of the substantive Teil, part, added to the numerals from 1 to 19 (the t is dropped in 8: Acht-el; ein Drittel, one-third, is irregular) and -stel to the numerals from 19 upwards: ein Fünf-tel, one-fifth; das Acht-el, the eighth; ein Zwanzig-stel, one-twentieth. The bisection of one (1) is denoted by ein Halb (half): ein halb-es Huhn, half a chicken (used adjectively and declined); zweieinhalb Pfund, two pounds and a half. The division with halves can also be expressed by the direct amalgamation of h a l b with the ordinal numeral; two and a half can be denoted by dritt(e)halb, in the sense of three with half of the last unit missing; viert(e)halb, three and a half, etc. One and a half is expressed by anderthalb, ander (the other one) being an ancient word for "the second." H a l b, half, and ganz, whole, when used as adjectives, are declined; the other fractionals add only -s in the genitive singular, and remain unaltered in all other cases. H a l b *never* precedes the article, but must *always* follow it: eine halbe Stunde, half an hour; ein halber Tag, half a day; etc. Halb and Ganz take no article before geographical names: halb Europa, half Europe; ganz Ameikra, the whole of America, etc.

LVIII. The Indefinite Numerals, wenig, a little; viel, much; all, alles, all; ein paar, a few; einige, some, several; jeder, jeglicher, jedweder, everyone; mancher, many a; keiner, none; etliche, several, are used as substantives and as attributive adjectives, and are declined as such. But wenig, little, and viel, much, remain at times undeclined when used poetically: Viel Steine gabs (gab es) und wenig Brotlaibe, literally translated: *Much* (instead of "many") stones there were and *little* (few) loaves of bread. Genug, enough; nichts, nothing; insgesamt, altogether; mehr, more; weniger, less, are not subject to declension. Beide, both, is declined like an adjective and is never *followed* by an article or pronoun: d i e

beiden Männer, both men, but never beide die Männer; meine beiden Söhne, my two sons, but not beide meine Söhne. Beide is also used substantively: Beide waren ehrliche Männer, both were honest men.

EXAMINATION PAPER XV.

1. Which suffixes denote the comparative and the superlative in the comparison of superiority, and is there any difference in the suffixes thus employed in English and in German?
2. Which preposition must be used with the superlative of adjectives used predicatively? What is then the case of the adjective?
3. How does the consideration of euphony affect the comparison of superiority of adjectives ending in -el, -en, -er?
4. Which adjectives take the suffix -est in the superlative, and which only -st?
5. What rule concerns the formation of the superlative of adjectives ending in -el, -en, -er, which cast off the -e- in the comparative?
6. Which adjectives modify their stem-vowel in comparison, besides taking a suffix?
7. When do they *not* modify their stem-vowel?
8. Which adjectives are irregularly compared?
9. Which is the conjunction used for the comparison of equality, and by what other word is it generally preceded?
10. Which conjunction has to be employed for the comparison of superiority?
11. How do the rules of euphony affect the formation of the comparative and superlative of adjectives terminating in -er?
12. How are the ordinal numerals from 1 to 19 and from 20 upwards formed?
13. Which ordinal numerals correspond to the cardinal numerals 1, 3, 8?
14. Which additions to the cardinal numerals serve to form the distributive, reiterative, multiplicative, variative, distinctive, and fractional numerals?
15. What difference is to be noted in the use of the article with the fractional numerals halb, half, in English and in German?
16. What is the origin of the addition made to the cardinal numerals in the formation of the fractional numerals, and how is this suffix spelt in the numerals from 1 to 19 and from 20 upwards?

EXERCISE 1 (*a*). Form the comparative of the following adjectives:

Der Tisch ist breit. Das Seil ist dick. Der Wein
The table is broad. The rope is thick. The wine
ist fein. Die Rose riecht herrlich. Wir kauften
is fine. The rose smells splendidly. We bought
schöne Blumen. Er sah traurig aus. Der Himmel
beautiful flowers. He looked sad. The sky
ist düster. Der Baum ist kahl. Das Schloß war lose.
is dreary. The tree is bald. The lock was loose.
Mein Pferd ist edel. Mein Pferd ist von edler
My horse is noble. My horse is of noble
Abstammung Er sandte mir einen flinken Boten.
descent. He sent me a quick messenger.
Ich sah ein schlankes Mädchen. Die Kerze brannte hell.
I saw a slender girl. The candle burnt brightly.
Mein Papier ist weiß und Ihres ist gelb.
My paper is white, and yours is yellow.
Nette Leute findet man selten.
Nice people are rarely (to be) found.

(*b*) Transpose the following positives into the comparative and superlative:

Das Pferd läuft schnell. Die Sonne Italiens
The horse goes [runs] swiftly. The sun of Italy
scheint hell. Ich wohne nahe, Der Ton klingt
shines brightly. I live near by. The note sounds
rein. Das Kind lernt fleißig. Der Ballon
pure. The child studies diligently. The balloon
steigt hoch.
rises high.

(*c*) Change the following positives into superlatives:

Dieses Kind ist eitel. Die Straße war eben.
This child is vain. The road was level.
Die Gesellschaft ist fröhlich und heiter. Der tiefe
The company is gay and merry. The deep
Brunnen war auch breit. Man muß vorsichtig sein.
well was also wide. One has to be careful.
Der Turm ist hoch. Das hohe Haus kostet viel.
The tower is high. The high house costs much.
Ich habe das gute Pferd gekauft.
I have bought the good horse.
Der edle Wein schmeckt gut.
The fine wine tastes well.

(*d*) Fill in the missing words and suffixes.

Ich bin . . . groß . . . du. Ich bin größer . . . du.
I am as tall as you. I am taller than you.
Sie sind . . . . . . liebenswürdig . . . Ihre Schwester.
You are just as amiable as your sister.
Sie sind liebenswürdiger . . . Ihr Bruder. Dieser
You are more amiable than your brother. This
Schüler ist weniger fleißig . . . jener, obgleich er
pupil is less diligent than that one, though he
. . . . alt ist . . . er. Das Haar des Mädchens
is just as old as he. The hair of the girl
war . . . licht . . . ein Kornfeld. Das Haar des Mädchens
was as fair as a cornfield. The hair of the girl
war lichter . . . ein Kornfeld.
was fairer than a cornfield.

EXERCISE 2 (*a*). Form the ordinal numbers of the following figures:

Ich war der 15 . . . in der Reihe. Der Offizier
I was the fifteenth in the row. The officer
las zuerst den 3 . . . Namen und dann den 8 . . .
read first the third name and then the eighth.
Es war am 21 . . . . Mai.
It was on the 21st of May.
Auf welchen Tag der Woche fällt der 1 . . April?
On what day of the week falls the 1st of April?
(What day of the week will April 1 be?)

(*b*) Spell the following fractional numbers: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$. $\frac{1}{7}$, $\frac{1}{8}$. $\frac{1}{18}$, $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{40}$; and express the following in figures: anderthalb, fünft(e)halb, viert(e)halb, sechst(e)halb, dritt(e)halb.

KEY TO EXAMINATION PAPER XIV.
(PAGE 2928)

EXERCISE. Ich blies die Trompete; du empfingst ihn; die Feinde fingen den Offizier; sie gefiel mir; das Kind wuchs; die Frauen wuschen die Wäsche; wer rief mich? Du liefst schnell; er stieß mich; wann kamt ihr? Der Bursche log; er schwur einen Eid. Was taten Sie? Ich ertrug es. Wir kamen eben nach Hause; ich tat meine Pflicht.

Continued

FISHES

Sharks and Rays. Sturgeons. Bony Fishes. Fishes as Parents. Lung Fishes. Lampreys and Hags. Lancelets, Sea-Squirts, and Acorn-headed Worms

By Professor J. R. AINSWORTH DAVIS

FISHES are aquatic, cold-blooded vertebrates, with a defensive armour of scales or bony plates embedded in the skin. They breathe throughout life by means of gills, which are delicate folds or filaments connected with openings (gill slits) in the sides of the throat. Flattened expansions of the body—*i.e.*, fins—are present,

340. PIKED DOGFISH
A. Dorsal fin *B.* Tail fins *C.* Pelvic fin *D* Pectoral fin
Photographed by Prof. B. H. Bentley

some of which, *unpaired*, are in the middle line, while others, *paired*, correspond to the fore and hind limbs of amphibians, etc. All the fins are supported by firm rods, the *fin-rays*.

Classification of Fishes. Four orders are recognised—namely, (1) SHARKS and RAYS (*Elasmobranchii*); (2) END-MOUTHED FISHES (*Teleostomi*), divided into the three sub-orders of (*a*) fringe-finned fishes (*Crossopterygii*), (*b*) sturgeons and their allies (*Ganoidei*), (*c*) bony fishes (*Teleostei*), including the most common forms—for example, salmon, cod, mackerel, eel; (3) LUNG FISHES (*Dipnoi*); (4) LAMPREYS and HAGS (*Cyclostomata*). The last two orders differ so much from the others that they are often considered as separate classes.

Order 1. Sharks. The sharks and their small allies, the dogfishes, are the typical members of this order [340]. The body is spindle-shaped, and well adapted to make its way through the water by wriggling movements from side to side. Propulsion is furthered by the largest of the unpaired fins—*i.e.*, the caudal, or tail fin, in front of which, on the upper side of the body, are two others of similar kind, the dorsals, which help to balance the fish in the water. The front pair of paired fins (pectorals) are capable of a certain amount of movement, and help in steering the course, while the hinder paired fins (pelvics) are subordinate aids to swimming.

The unsymmetrical shape of the tail fin is particularly noteworthy, and is well seen both in the illustration of a dogfish [340] and that of a porbeagle shark [341]. These creatures are chiefly ground-feeders, and when they swim forwards without steering this sort of tail enables them to move directly downwards to the sea floor, which constitutes their chief area of operations. But by appropriate movements of the pectorals they can also swim straight ahead or obliquely upwards as may be desired.

It is characteristic that in members of this order the mouth should be on the under side of the head, a somewhat inconvenient situation, since to seize its prey the fish is obliged to turn over on to its back. Five gill slits are visible on either side in front of the pectoral fin [342], and just behind the eye there is an aperture known as the *spiracle*, which is the opening of a gill slit that is losing its use as a breathing organ, and serves to conduct waves of sound to the internal organs of hearing possessed by these fishes [340 and 342].

342. HEAD OF SHARK
Showing (*A*) five gill slits

Tough Skin and Flesh. The skin of a shark or dogfish is extremely rough, owing to the presence of little bony structures, the placoid scales, which closely resemble teeth in nature. Indeed, near the edges of the jaws they gradually pass into teeth, which may be considered as evolved from modified scales—from which it follows that the possession of teeth by mammals, reptiles, and amphibia points to their descent from fish-like ancestors. Owing to the fact that the skin of a shark is full of sharp scales, it is capable of being used, under the name of "shagreen," for various polishing purposes. The skin is also used in the manufacture of a kind of leather employed for ornamental purposes.

341. SKELETON OF PORBEAGLE SHARK
A. Dorsal fin *B.* Tail fin *C.* Pelvic fin *D.* Pectoral fin *E.* Gill arches *F.* Eye *G.* Jaws

Sailors have long been in the habit of indulging in shark steaks, and the question has lately been raised as to whether dogfishes, the plague of fishermen, might not be used as food. The question can no doubt be answered in the affirmative, and, as a matter of fact, these fishes are often exposed for sale in some of our ports—Dover, for example.

Rays and Skates. These well-known fishes [348], rhomboidal in form, with a long, slender tail, are closely related to the sharks and dogfishes, with which they are connected by a series of transitional forms. They constitute an important article of diet. The edible part, from which "crimped skate" is prepared, consists of the triangular sides or "wings" of the body, which are no other than the enormously enlarged pectoral fins. Sharks, dogfishes, and skate alike, are "gristly fishes," their skeletons being mostly composed of gristle, commonly hardened by the deposition of salts of lime.

The eggs of these forms are large, owing to the presence of a great deal of nutritive matter (food-yolk). They are fertilised internally, and may either develop within the body of the mother or be laid in horny cases, known popularly as "mermaids' purses" [369 A and B.]

Order 2. End-mouthed Fishes. The name of this order is derived from the fact that, as a rule, the mouth has been shifted forwards to the front end, which is undoubtedly the most convenient place for it. The gill slits are protected by a flap, the gill cover or operculum, and the skeleton is more or less bony. A swim-bladder containing air is commonly present, its primary use being to help in balancing.

The three sub-orders must be considered separately.

(*a*) **Fringe-finned Fishes.** These ancient forms are so called because the paired fins are in the form of large paddles bordered by a membranous fringe supported by fin-rays. At a remote epoch of the earth's history they were represented by numerous marine types, but by pressure of competition were gradually driven into estuaries and rivers, and now only include two freshwater African fishes. These are the bichir of the Nile (*Polypterus*) [343] and the slender reed-fish (*Calamoichthys*) [372], which lives in the rivers of Old Calabar. These forms are covered by rhomboidal bony plates, the tail fin is rounded, and there is a series of little finlets, each supported by a strong spine in front, running along the middle of the back.

(*b*) **Sturgeons, etc.** Here are included a small number of primitive fishes inhabiting the fresh waters and estuaries of the Northern Hemisphere, and in many cases so dissimilar that they would not be grouped together if it were not for the evidence afforded by extinct forms. This clearly shows that they are the surviving remnants of what was once a dominant marine group, and owe their preservation to the fact that they have taken refuge in the waters of the land, where the struggle for existence is not so keen as in the sea.

We may employ the term "ray-finned" in describing these fishes, for the thickened bases of the paired fins are largely absorbed into the body, so to speak, while their projecting parts are thin and supported by diverging fin-rays. The bony pike (*Lepidosteus*) of North America is clothed in bony armour, and its strongly toothed jaws are drawn out into a sort of narrow beak [350]. The widely distributed sturgeons are distinguished by the possession of a long snout, used apparently for stirring up mud in order to secure worms and other small creatures as food. The small mouth is on the under side of the body, as in sharks, to which another resemblance is afforded by the extremely unsymmetrical tail, in relation to the ground-feeding habit. Armour is sometimes entirely absent, or may be represented by large keeled plates, as in our only native form, the common sturgeon (*Acipenser sturio*) [346] sometimes to be seen in fishmongers' shops. The swim-bladders of European species are made into isinglass, and their hard roes are salted to be sold as caviare.

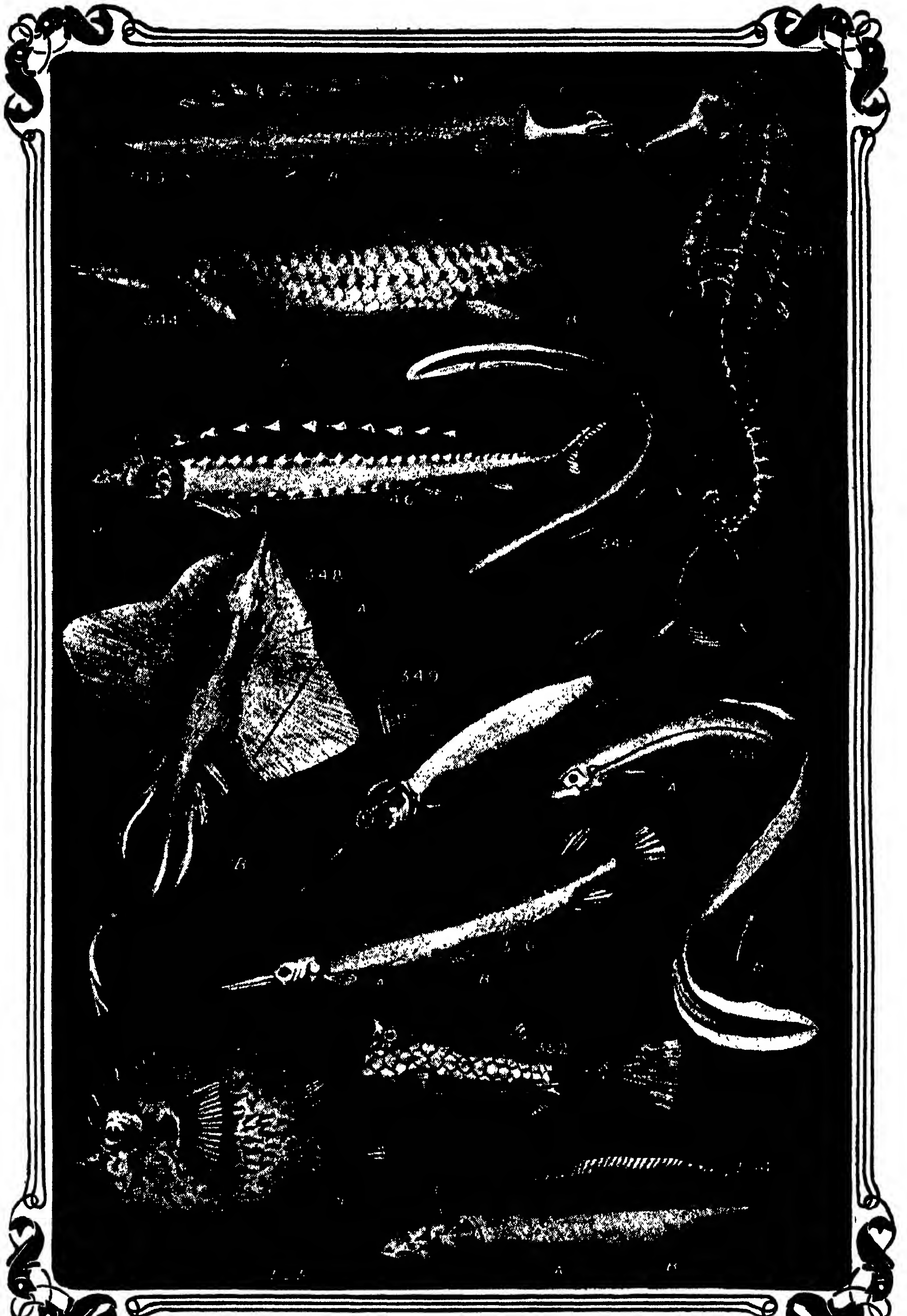
The bow-fin (*Amia*) of North America is not so archaic in appearance as the forms so far considered. The tail is rounded, and the body covered with thin flexible overlapping scales [354].

(*c*) **Bony Fishes.** This large and dominant group, which still appears to be on the up grade, includes the great majority of existing species, and represents the most perfect product of evolution, so far, along the fish line. It is true that sharks and rays (including something less than 300 species) are still flourishing, but the important forms now to be considered embrace no less than 7,000 species, in round numbers.

The distinctive characters of bony fishes can largely be explained as adaptations to swift and accurately directed swimming. Some of them will readily be appreciated by examination of a herring [355], trout [356], or mackerel. The body is shaped like a rounded wedge, somewhat flattened from side to side, and eminently suited for sliding through the water with the minimum of friction.

Friction is still further reduced by the covering of thin flexible horny scales, bathed in a slimy secretion. Propulsion is effected by lateral undulations of the body, the effect of which is greatly enhanced by the powerful tail fin. The cumbrous armour-plating of the more ancient types has of necessity been abandoned, though it has been reacquired by a few sluggish forms, and safety from foes is sought in speed rather than in defence. But as adequate support is required by the body and firm attachments for the powerful muscles, the loss of a strong external skeleton is fully compensated for by the presence of a very elaborate internal skeleton largely consisting of bone [357].

The task of supporting the body in the water is to some extent lightened by the presence of a swim-bladder situated immediately below the backbone, obviously the best position for maintaining the balance. This organ is in reality a pouch which grows out from the front part of the digestive tube, with which it may remain connected throughout life, as in the herring, or else get separated off, as in cod.



REPRESENTATIVE FISHES: I.

343. Bichir (*Polypterus*) **344.** Australian Lung Fish (*Ceratodus*) **345.** Seahorse (*Hippocampus*) **346.** Common Sturgeon (*Acipenser sturio*) **347.** Hag (*Myxine glutinosa*) **348.** Ray **349.** Swordfish **350.** Bony Pike (*Lepidosteus*) **351.** South American Lung Fish (*Lepidosiren*) **352.** Coffer Fish (*Ostracion*) **353.** Globe Fish (*Diodon*) **354.** Bow-fin (*Amia*)
A. Pectoral fin *B.* Pelvic fin *C.* Gill cover *D.* Mouth *E.* Pouch

Parachuting Fishes. It is particularly interesting to notice that in these fishes the tail fin is externally symmetrical, so that in unsteered swimming the course is straight ahead. A remarkable exception is afforded by the flying fishes, where the forked tail is markedly unsymmetrical, but with a large *lower* lobe, clearly for the purpose of giving an upward tendency to undirected swimming [358]. And it is well known that these fishes, especially when pursued by their enemies, are in the habit of rising out of the water, and remaining for some time in the air, to which their enormous fore fins, used as parachutes—not as wings—offer a very large supporting surface.

There can be no doubt that backboned animals were originally evolved in the sea, and it is therefore only to be expected that the organs of respiration and circulation in fishes should have become adapted to an aquatic life. Indeed, as we have previously had occasion to notice, the backboned animals of the land have been obliged to grapple with the difficulty of modifying the fish type of circulatory organs to suit the exigencies of terrestrial life. Amphibians and reptiles have done this to some extent, but only birds and mammals have completed the process, and it is to this fact that their success in life is due.

356. TROUT

A. Gill cover *B.* Pectoral fin *C.* Pelvic fin
Photographed by Prof. B. H. Bentley

Structure of Gills. Anyone who takes the trouble to lift up the gill cover of a herring or other bony fish will at once see several comb-shaped aggregates of scarlet gill filaments, collectively presenting a large surface for the purification of the blood [366]. They are attached to narrow bony bars, between which are the gill slits. The course of the water used in breathing can easily be observed in an aquarium of goldfish. It is taken in at the mouth, passes through the gill slits over the gills, and thence to the exterior. The heart receives impure blood from all parts of the body, pumps it to the gills for purification, and from these it flows to all the organs.

Many points in the life histories of bony fishes are worthy of special study. The small eggs are fertilised externally, and in the large majority of marine species float on the surface of the water, though some of them —for example, those of the herring, are sticky and adhere to stones, etc., on the bottom.

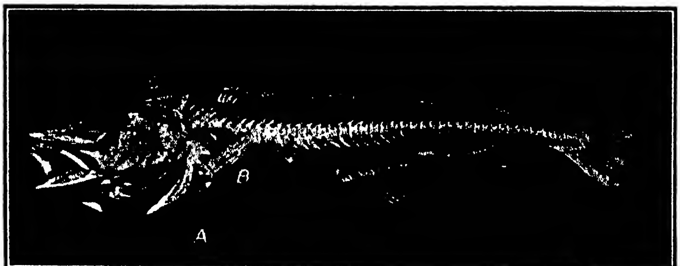
355. HERRING

A. Pelvic fin *B.* Pectoral fin *C.* Gill cover
Photographed by Prof. B. H. Bentley

In some of the shore fishes, such as the little blennies, they are enclosed in protective capsules [359]. The fry, or larvæ, which hatch out from the eggs are very unlike the adults in appearance, and have to pass through many changes before acquiring the characters of the species to which they may happen to belong [360]. Both eggs and fry are eagerly sought out as food by a host of enemies, but they are produced in immense numbers, so that extinction is prevented. The hard roe of a cod, for instance, has been calculated to produce over nine million eggs each season.

Colouration. The colouration of fishes is to a large extent protective, rendering them inconspicuous by harmonising with the surroundings. Seen from above, the darker upper side is confused with the dark sea-floor; seen from below, the white or pale under surface blends with the glimmering background caused by the penetration of light into the water; seen from the side, the "reversed shading" takes away from the appearance of solidity, as already described for many of the backboned animals of the land. In many cases the colours change to suit different surroundings. During the spawning season some fishes, usually the males, assume bright courtship colours. The most familiar example is that of the little sticklebacks (*Gasterosteus*) of our inland streams [361], in which at this time the male (then known as a "robin") arrays himself in a scarlet livery, and is unusually pugnacious, fighting to the death other suitors who attempt to interfere.

Care of the Young. Parental affection among fishes is usually notorious by its absence. But to this there are some honourable exceptions, and in such cases fewer eggs are produced, for each has a better chance of hatching out into a larva destined to attain maturity. In one of the freshwater catfishes (*Aspredo*), for example, the eggs are attached to the roughened under surface of the mother's body.

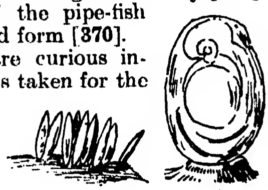


357. SKELETON OF A CODFISH

A. Pelvic fin *B.* Pectoral fin *C.* Gill co

Strange to say, however, it is to the paternal side that we must mostly look for examples of the care of eggs or young. The sticklebacks are well known in this connection. The male constructs a muff-shaped nest, made up of fragments glued together by a sticky secretion of the kidneys [361]. In this his wives lay their eggs, which he jealously guards till they hatch out, a procedure rendered necessary by the depraved cannibalistic tendencies of the females, and when the tiny fry emerge he protects them for some time. The male of the curious little seahorse (*Hippocampus*), which holds on to seaweeds by means of its curly tail, has a sort of pouch on the under side of the body in which the eggs pass through their development, and which serves as a city of refuge for the fry [345]. The same is true of the pipe-fish (*Syngnathus*), a related form [370].

Salmon and eels are curious instances of precautions taken for the benefit of the rising generation. It is a familiar fact that the former ascend rivers to spawn, the eggs being deposited in a sort of trench scooped out in the gravel or sand at the bottom. Exactly the reverse is true of eels, for it has been discovered of late years that they descend rivers to spawn in the deep sea, from which later on the little "elvers" return to the proper home of the species.



359. EGG CAPSULES OF BLENNY
A. Enlarged

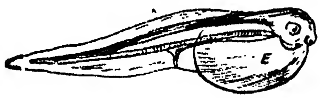
Adaptation to Circumstances. The great bulk of bony fishes resemble the herring and trout in shape, but there are, of course, considerable differences in detail, which may be illustrated by comparing the blunt-headed gurnards [368] with the sharp-snouted sword-fishes [349]. There are also very considerable variations in the character of the fins, and even their number in the case of those which are unpaired. The original position of the hind fins (*pelvics*) appears to have been pretty far back [356], but there is a tendency for them to shift forwards, till in some cases they lie under the throat [357], being actually in front of the fore fins (*pectorals*).

But there are far more considerable deviations from the average type than those just mentioned. Sometimes the body is long and narrow as in pipe-fishes [370] and eels. In the former an advantage is gained when prey is being stalked on the sea-floor, for a body so shaped is very inconspicuous when seen from the front. The slimy cylindrical eel can easily wriggle through mud in the search for worms and molluscs. The seahorse (*Hippocampus*) [345], a fairly near relative of the stickleback, is sufficiently remarkable. The long axis of the body is here directed upwards, and the head has been sharply bent down, as otherwise it would be in an unfavourable position for seeing and seizing food. This curious little fish is able to swim in a vertical position by the rapid movement of the dorsal fin from side to side.

361. NEST OF STICKLEBACK

358. FLYING FISH

Methods of Securing Food. Sometimes the head is of disproportionate size, as in some forms which are not good swimmers, but lurk under stones or elsewhere on the look-out for prey. The bullheads of our shores and streams are examples of this. A still more conspicuous case is that of the angler-fish or fishing-frog (*Lophius*) [364], which half buries itself in sand or mud, awaiting the approach of little fishes, which are attracted by a peculiar "lure" constituted by a much elongated fin-ray with a flap at the end. Such curiosity is commonly fatal, and there is no escape from the huge mouth with its long, sharp backwardly-curved teeth, which bend down to facilitate entry, but render exit almost impossible. There are some deep-sea anglers in which the lure is phosphorescent.



360. WRASSE JUST HATCHED
E. Yolk sack

Sometimes the body has acquired a rounded shape, as in the globe fishes (*Diodon* and *Tetrodon*) of tropical seas [353]. These are able to blow themselves up with air, and drift about back downwards, with their sharp spines erected for defensive purposes. The coffer-fish (*Ostracion*) also deviates from the normal type, and is further distinguished by its armour of bony plates [352].

A considerable number of bony fishes are flat in shape, the flattening being from side to side, not from above downwards, as in skates and rays. Some such forms—*e.g.*, the John Dory (*Zeus faber*), swim with the body vertically disposed, and are likely to escape the notice of prey which happen to be in front of them; but the flat fishes par excellence (turbot, sole, plaice, etc.) are ground forms which, so to speak, lie down on the right or left side of the body, and either shuffle along or swim by undulating movements. In a plaice, for example, the dark surface of the body, mottled with orange spots, is not the upper but the right side [362], while the pale left

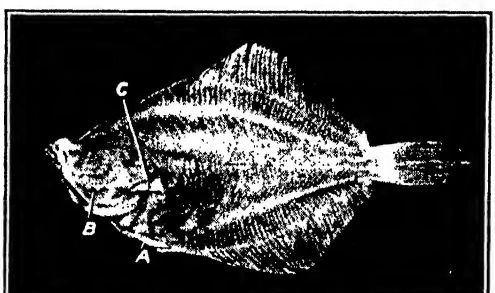
side [363] is directed downwards. It is obvious that the left eye, if retained in its proper place, would not merely be useless but liable to injury by friction against the sea-floor, and in the course of development it moves round the edge of the head on to the right side. To begin with, the young fish is symmetrical, and swims in the usual fashion, but gradually becomes lop-sided and takes to living on the bottom. It is then that the left eye shifts its position. In most flat fishes both eyes are on the right side, as in the plaice, but in turbot and brill they are on the left.

The most remarkable and weird-looking bony fishes live at great depths in the sea, and suggest dream visions caused by acute indigestion rather than matter of fact living beings. We give illustrations of stomias [365], malacosteus [373], macrurus [374], and saccopharynx [367]. They are extremely voracious, with huge mouths and business-like teeth, and their eyes are either very large or much reduced, sometimes indeed absent. Many are studded with phosphorescent organs, and without light of this kind, supplied by various creatures, the abyss of the ocean would probably be pervaded by the profoundest gloom. Probably these unfortunate creatures have been driven into the deep sea from shallower waters by the stress of competition, and their peculiar characters are adaptations to an unusual sort of life. Eyes capable of improvement have gradually acquired an enormous size, while eyes incapable of this have been more or less reduced.

362. THE RIGHT SIDE OF A PLAICE
A. Left eye *B.* Right eye *C.* Pectoral fin *D.* Pelvic fin *E.* Gill cover
Photographed by Prof. B. H. Bentley

Order 3. Lung Fishes. It may be taken as an axiom that in all cases where more or less impure blood is separated by a thin membrane either from air or from water in which air is dissolved a certain amount of respiration will take place—that is to say, oxygen will diffuse into the blood, and the waste product, carbonic acid gas, will diffuse out of it. The swim-bladder of fishes offers an opportunity of this kind, for numerous blood-vessels run in its walls, and it contains air, or a mixture of gases, of which one is oxygen. It is well known that in the Polypterus of the Nile, the bow-fin of the North American lakes, and certain bony fishes inhabiting fresh water, breathing is furthered in this way. The process has gone a stage further in the lung fishes, which are at present represented by three freshwater types, the insignificant remnant of a group that was once dominant in the sea, and would have become entirely extinct if some of its members had not taken to live in the waters of the land. These types are the eel-shaped mud-fishes of West Africa (*Protopterus*) and South America (*Lepidosiren*) [351], and a Queensland form (*Ceratodus*) [344]. In all these the swim-bladder has been converted into a regular lung which returns purified blood to the heart. The African form lives in streams which are liable to dry up, and were it not for the possession of a kind of lung capable of breathing air would perish during the dry season; whereas it remains embedded in the mud in a torpid state till the rains return. They are eaten by the natives, who dig them out of the mud. Enclosed in their covering of clay, they have been brought alive to this country.

The Queensland lung fish lives under somewhat different conditions, for its native rivers do not entirely dry up, but are reduced to a series of deep holes connected by mere trickles of water. These holes become so foul from decaying vegetation and dead fish that the possession of a lung is a vital matter, and if the ceratodus were not able to come to the surface and breathe air it would probably succumb.

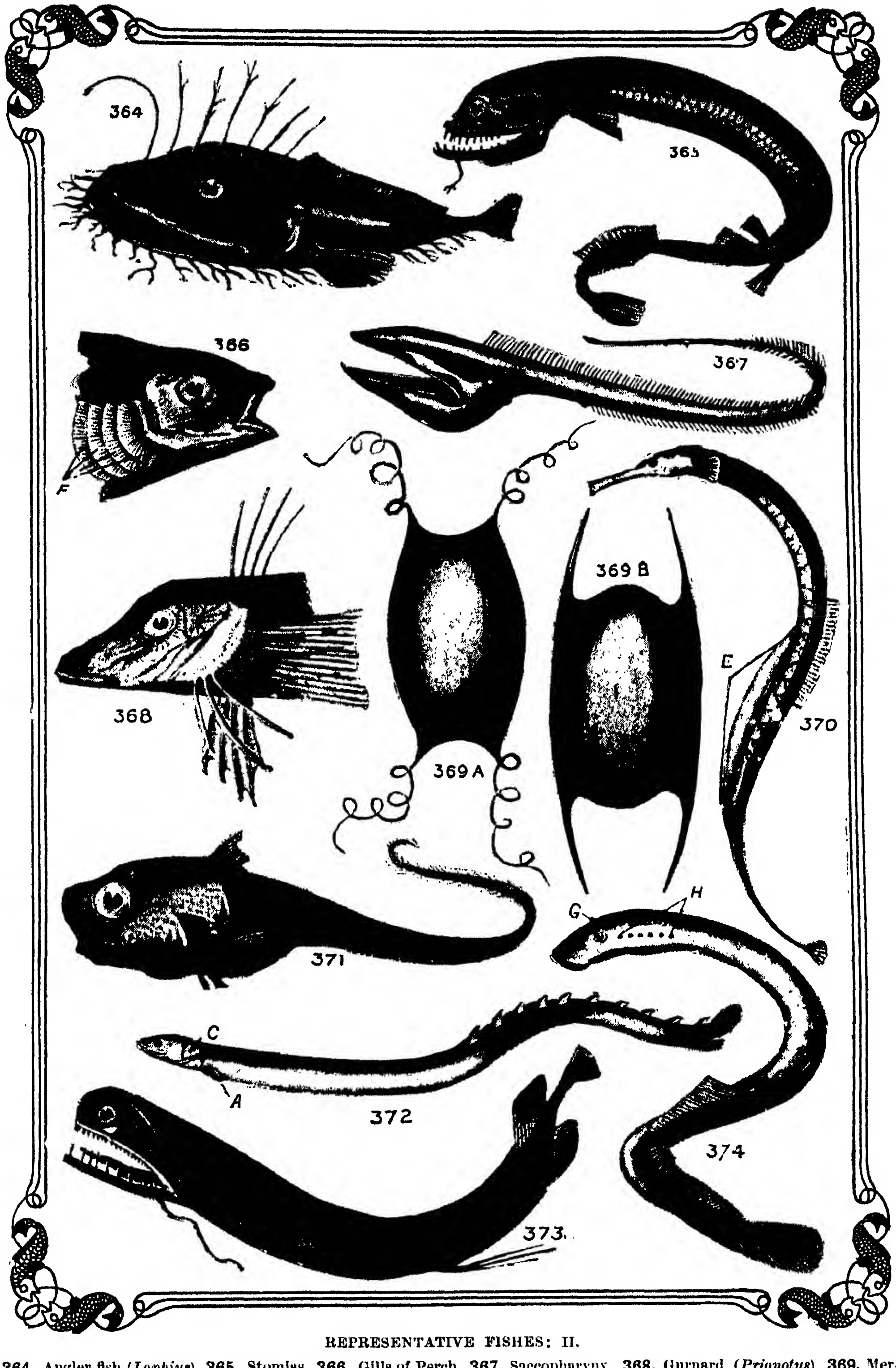


363. THE LEFT SIDE OF A PLAICE
A. Pelvic fin *B.* Gill cover *C.* Pectoral fin
Photographed by Prof. B. H. Bentley

Order 4. Lampreys and Hags. These eel-shaped forms are represented in Britain by the freshwater lampern (*Petromyzon fluviatilis*), the sea lamprey (*P. marinus*) [374], and the marine hag-fish (*Myxine glutinosa*) [347]. All of these are jawless, and the mouth is in the middle of a sort of sucker, studded with horny teeth, some of which are also present on a so-called tongue. By means of the sucker they attach themselves to living prey, scraping away the flesh with the tongue.

PRIMITIVE BACKBONED ANIMALS

There are three chief features by which backboned animals are distinguished—namely, (1) the central nervous system is tubular and situated near the upper side of the body; (2) underneath part or all of this a longitudinal supporting rod, the *notochord*, is present at



REPRESENTATIVE FISHES: II.

364. Angler fish (*Lophius*) **365.** Stomias **366.** Gills of Perch **367.** Saccopharynx **368.** Gurnard (*Prionotus*) **369.** Mermaids' Purses (A Dogfish; B. Skate) **370.** Pipe-fish (*Syngnathus*) **371.** Macrurus **372.** Reed-fish (*Calamoichthys*) **373.** Malacosteus **374.** Lamprey (*Petromyzon marinus*)

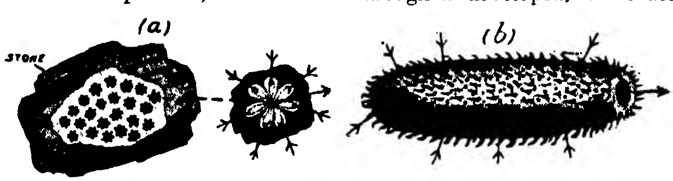
A. Pectoral fin *C*. Gill cover *E*. Pouch *F*. Gills *G*. Nostril *H*. Gill slits

some time or other during life, being, as a rule, entirely or partly replaced by a backbone in the adult; (3) the throat is perforated by gill slits during part or all of life. If these characters are taken as tests the backboned animals include not only mammals, birds, reptiles, amphibians, and fishes, but also three other groups, the members of which are unfamiliar to all but specialists. These are: (1) LANCELETS (*Cephalochorda*); (2) SEA-SQUIRTS or ASCIDIANS (*Tunicata*); (3) ACORN-HEADED WORMS (*Hemchordai*), etc.

375. LANCELET (*Amphioxus*)
A. Tail fin B. Mouth

376.
SIMPLE SEA-SQUIRT
The arrows indicate the course of the water

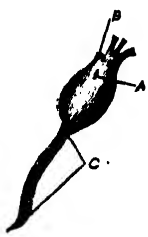
Lancelets. The Lancelet (*Amphioxus*) [375] is a little flattened animal some two inches long, of very wide distribution, and formerly considered as a primitive sort of fish. It is in possession of all three characteris ics mentioned above, but, like the lampreys and hags, and all primitive backboned animals, is jawless. It is sharply pointed at either end, whence the name, and burrows in shallow water where the sea bottom is sandy. When feeding it is embedded in the sand in a vertical position, and water flows into its bell-shaped mouth, serving both for breathing purposes and also to convey the minute organisms which serve as food.



378. COLONIAL SEA-SQUIRTS (*a*) Fixed (*b*) Free swimming

Sea-squirts. Living in the sea, and attached to various objects, are to be found a number of curious animals resembling in shape one of the wine-skins of ancient times, and covered by a tough protective investment [376]. There are two openings in the body, into one of which currents of water continually flow for feeding and breathing purposes, while waste products of all kinds are as continually swept out of the other. On dissection we find that the equivalents of gill slits are present, but there is nothing to represent a backbone, and the central nervous system consists of a little thickening between the two openings of the body, which is no help to classification. From the eggs of this curious creature, tadpole-shaped larvæ [377] hatch out, which satisfy all three of our tests except that the notochord is limited to the tail region. Later on they become attached, lose their tails and notochords, and at the same time the central nervous system becomes reduced. We have here, in fact, a good example of degeneration, due to the enervating influence of a fixed or sedentary life, which reduces the necessity for individual effort.

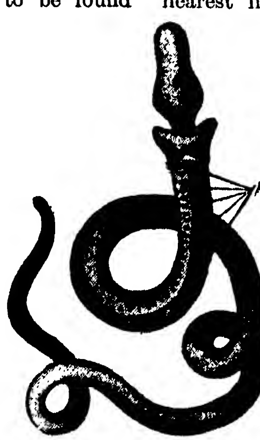
Many of the sea-squirts are colonial, consisting of a number of individuals connected together, and these may be either attached or free-swimming [378].



377.
TADPOLE LARVA OF SEA-SQUIRT

Acorn-headed Worms, etc. The best-known members of this small group are the acorn-headed worms (*Balanoglossus*) [379], which burrow in mud by means of the projecting front end of the body, which alternately elongates and shortens, the second process pulling the animal forward. A short elastic rod by which this region is supported possibly represents a notochord, while numerous gill slits are to be seen on the upper side of the body, and the central nervous system, though ill-developed, is situated as in typical backboned animals.

These creatures are protected by a disagreeable smell, and are brightly coloured the two sexes differing in this respect. They are, perhaps, the nearest living representatives of the ancestral stock from which all backboned animals have descended.



379. ACORN-HEADED WORM (*Balanoglossus*) A. Gill Slits.

Unfortunately, traces of such soft creatures are hardly ever found preserved in the "record of the rocks," so that there is a good deal of scope for speculation.

It is a matter of great doubt which group of the innumerable backboneless animals, which we must next consider, comes closest to the backboned forms. There are, however, certain unsegmented marine worms (*Nemertines*), devoid of gill slits, notochord, and hollow central nervous system placed dorsally, but approaching backboned animals in some respects.

Continued

WARS ABROAD & STRIFE AT HOME

Henry III. and the War with the Barons. Welsh and Scottish Attempts at Independence. The First Prince of Wales. Beginning of the Hundred Years War

Continued from page 2948

By JUSTIN McCARTHY

HENRY III., who succeeded his father, King John, in 1216, was born on October 1st, 1207, and was only a child when he became nominal ruler of England. The State affairs were managed meantime by a regent, but in 1227 Henry declared himself of age, and took the control of the realm into his own hands. He became engaged in a war with France, and, not getting the better of his opponent, might have come to severe loss had not the French sovereign, Louis IX., behaved with remarkable forbearance and generosity.

Henry was not an estimable sovereign. He was surrounded by favourites and parasites, and was sometimes reckless in the extortion of money to maintain his own prodigal expenditure. He did, indeed, adopt and proclaim the Great Charter, but he made his confirmation of it an excuse for obtaining a new money grant.

The Barons' War. The reign of Henry was made famous by the struggle known as the Barons' War. Henry's extortions and other caprices had exhausted the forbearance of the barons, whose Order held a constitutional position already, and in 1258 Parliament, led by Henry's own brother, Simon de Montfort, Earl of Leicester, rose against him, and enacted a series of statutes which they strove to make the King accept, and under which Henry was compelled to hand over his power to a commission of the barons. Henry kept terms for a short time, but disunion soon arose among the barons, and Henry took advantage of this to repudiate his contract and to break his oath. Then followed a struggle between the King and the barons, as a result of which, neither gaining anything that could be called a victory, the question was referred to the arbitration of the sovereign of France, who gave judgment in favour of Henry.

Beginning of Representative Government. But de Montfort was not content to let the matter end so easily. He collected his forces, and with the help of London and other English towns, he denounced the arrangement come to with the French King, attacked King Henry's army at Lewes, and captured Prince Edward, the King's son. Then it was arranged that the settlement of the country should take place under the control of three electors—Simon de Montfort, the Earl of Gloucester, and the Bishop of Hereford—by whose nomination nine councillors were to be appointed for the formation of a Ministry. In order that this should have the approval of the whole kingdom a sort of parliament was to be called together, in which, along with the barons and the prelates, there were to sit four knights chosen from each shire, and, for the first time in England's history, two representatives from some of the larger towns. The whole system of our modern representative government in the House of Commons may be said to trace its origin from this definite attempt to construct a parliament.

Death of Simon De Montfort. The experiment scarcely came into actual organisation. The barons could not endure the supremacy of De Montfort, and King Henry, allying himself with some of them, took arms against Simon. Simon was defeated at Evesham on August 12th, 1265, and was killed on the field of battle. De Montfort was regarded by a large proportion of the people, and by the clergy in general, as a saint, and there are legends that miracles had been wrought by him. There was much in Simon's character which does not reconcile itself with modern ideas of sanctity, but he undoubtedly had the genius of a great constructive statesman, and foresaw the course which the constitutional development of Britain was destined to take.

Henry's reign lasted until 1272, when he died at Westminster. He was in a sense a fortunate sovereign—fortunate in the fact that his reign coincided with the opening of some great institutions which must ever be associated with England's advance in civilisation.

In his reign, although not by his inspiration, the first organised attempt to create a parliamentary system was made and, to a certain extent, carried out in England. By him, also, the first charter to the University of Oxford was granted. The belief that King Alfred founded the schools out of which the University grew is not now regarded by historians as other than a legend which naturally attached itself to Alfred's well-deserved fame. King Henry deserves credit for having encouraged the movement which led to the establishment of the Universities, but he cannot be regarded as the creating influence in that great development of England's national progress. The growth of the University of Cambridge goes back to the mythical period, and all that can be said of King Henry is that in the instance of Cambridge and of Oxford he gave his Royal sanction and support to the system. His name will probably be best remembered in history because of this and of the encouragement which he gave to the elevation of school teaching.

Accession of Edward I. Edward I. succeeded Henry in the natural course, for Edward was the elder son. He was born at Westminster, June 17th, 1239. On his marriage he received from his father the rulership of Gascony, Ireland and Wales. His earliest education in the business of war was received in Wales, where there was at the time much

disturbance. In the opening of the struggle against Simon de Montfort Edward took part with his father, but he afterwards lent his support to some of the conditions insisted on by De Montfort. He took part in the last crusade, distinguishing himself there as a knight, and it was on his return that he heard of the death of his father, which had taken place two months before.

Edward's Foreign Policy. When he returned to England, and had gone through the ceremony of coronation, he received the homage of the King of Scotland, Alexander III.; but it was remarked that Prince Llewelyn of Wales did not offer his homage until long after. It was then one of the institutions of the time that the rulers of Scotland and of Wales should be regarded as holding the crowns under the over-rule of the Kings of England. Edward was soon to be engaged in a war for the complete conquest of Wales, and its settlement as a part of the English Kingdom. The King afterwards proved that his principle of government was to give up altogether the idea of holding by force the foreign territories which his predecessors had won and had always struggled to maintain, and at the same time to devote all his energy and capacity to consolidating England, Scotland, Wales, and Ireland into one kingdom. The first task to be accomplished was the conquest of Wales. There had been continual risings in different parts of Wales against the authority of England, and when Edward I. succeeded to the throne these risings began to assume the form of a Welsh national movement.

Last Struggle for Welsh Independence. Llewelyn, the Welsh Prince, stood out against Edward and the army of the English sovereign invaded North Wales. The difficulties then to be encountered were too great for the Welsh resistance. Wales was divided into localities with separate chieftains, and it was hardly to be expected that all these should hold firmly together in support of a policy which might end in making them mere vassals of the Welsh prince if he should succeed in making his country independent of England. Llewelyn was defeated, and died on the field during a great battle in December, 1282. This defeat closed, to all intents and purposes, the struggle of Wales for independence.

Edward made on the whole a wise and generous use of his victory. He applied himself to establish trade guilds in the Welsh towns; to introduce the best forms of English jurisprudence into Wales; to divide the country into counties and shires, according to the methods prevailing in England, and to abolish some of the barbaric customs which still struggled against growing civilisation. The story that Edward ordered a massacre of the Welsh bards to prevent them from stirring up their people into another rebellion is now regarded as mere fable. The effect of his policy was, for the most part, satisfactory. The good relations between England and Wales did not remain undisturbed for ever after—in these days there were few countries in which domestic peace remained for long unbroken—but no part of England's dominions gave her less trouble during the years to come than that which had been made part of Great Britain by the policy and the action of Edward I.

The Dispute for the Scottish Throne. Edward had a more severe struggle to encounter in Scotland. A dispute had arisen for the succession to the Scottish Crown on the death of the young queen, who had been betrothed to Edward's son, and this claim appears to have suggested to Edward the opportunity of setting up his own claim to the sovereignty of Scotland. The claimants to the throne of Scotland were Baliol, descendant of a great Anglo-Norman family, some members of which had held succession to the crown of Scotland for a long time, and Robert Bruce, Lord of Annandale, whose name is best preserved to fame by that of his grandson, Robert Bruce. Edward was invited to act as arbiter between the rivals, and he declared Baliol to have the higher claim.

Baliol was not long content with his position as subordinate to the over-rule of the King of England, however, and events gave him the opportunity which he was seeking. The French king, Philip IV., who had just begun to reign, made an effort for the recovery of all French lands from the English. Philip soon made open preparations for war. Thereupon the Scots, under Baliol, determined to take advantage of the chance thus offered to them, and there was soon war between the two countries. Edward invaded Scotland; Berwick was captured, but not without fierce resistance and much slaughter. The rest of the work, so far as that invasion was concerned, became comparatively easy. Edinburgh, Stirling, and other cities, opened their gates to the conqueror, and Baliol surrendered, and was consigned to an English prison.

Battle of Stirling Bridge. The real struggle, however, was yet to begin. William Wallace, the famous Scottish patriot, the descendant of a powerful Scottish family, made himself the leader of a movement against King Edward, which had purposes at once more direct and broader than those avowed by Baliol. Wallace went in for the complete freedom of Scotland from English dominion, and gathered around him a great force of patriotic followers. He defeated one of Edward's generals, the Earl of Surrey, in the battle of Stirling Bridge, and the whole Scottish kingdom then declared in favour of Wallace's leadership. The Scottish chief crossed the Border and carried the war into England, as far, at least, as Newcastle. He returned to Scotland, and was there proclaimed governor of the country in the name of King John, King John being the Baliol who had been unable to make his own Royal claims effective. The appointment conferred on Wallace was declared to be given by consent of the Scottish nation. King Edward was not a man to be easily put off any enterprise he had undertaken, and was, indeed, in the military sense, a foeman worthy of the Scottish hero's steel. Edward invaded Scotland with an army

of some 90,000 men, and Wallace, taken by surprise at this sudden and tremendous effort, was compelled to give battle whether he would or no, and underwent a total defeat at Falkirk. Wallace escaped to France, but did not remain there long. Returning to Scotland, probably in the hope of making some new effort, he was captured near Glasgow by one of Edward's Scottish governors, and carried a prisoner to London. There he was tried for high treason in Westminster Hall, found guilty, and sentenced to death in 1305.

Execution of Wallace. The sentence was carried out after a fashion which would now seem only worthy of a barbarous nation. The head of the illustrious Scotsman was cut off, and, having been derisively crowned with a chaplet of laurel, was set at the top of a pillar on London Bridge, while the body was disembowelled and quartered, the quarters being sent as a sort of warning to Newcastle, Berwick, Stirling, and Perth. Edward was generally inclined towards acts of mercy, and it is said in his defence that he was willing to show mercy if Wallace would have made some act of submission to his conqueror. But Wallace refused to make any submission, and stood up for his cause in the court where he was tried as he would have done on the battlefield.

Edward showed magnanimity in his manner of dealing with the Scottish people after he had got rid of Wallace. Some course had to be adopted for the reconstitution of Scotland under the new conditions, which no doubt Edward believed to be complete and lasting. A new form of government had to be arranged, and Edward entrusted the government of the country for the time to a council of Scottish nobles, several of whom had taken part in the war against England, but who were pardoned and invited to help in the re-establishment of peace and order.

Edward had in mind an entirely new constitution for Scotland, one principle of which was the representation of the Scottish people in the Parliament of England. This movement, however, did not come to any success. The longing of Scotland for actual independence was still fervid and unsubdued, and a man was soon to come to the front who could give it a more powerful expression. This man was Robert Bruce.

Edward did not live to see the more serious part of the struggle. He was in weak health, and was sinking into years, but he was making preparations for still another Scottish invasion when he died on July 7th, 1307.

The First Prince of Wales. He was succeeded by his son, Edward II., born in 1284, and in 1301 created Prince of Wales, the first heir-apparent to the British Throne who bore that now historic title. This first Prince of Wales had not in his early years given any promise of a successful rule; he had associated himself with unworthy favourites, one of whom, Piers Gaveston, acted in so lawless and shameless a fashion that the nobles of England rose against him, and demanded his banishment. When he returned to England, and endeavoured to regain his former position, they compelled King Edward to assent to his execution.

Robert Bruce had sworn fealty to Edward I., and had even served in his army; but he joined the Scottish uprising under Wallace, and when that movement had ended, he appears to have accepted the new arrangements by which Edward I. endeavoured to bring about a final settlement between the two countries.

In those days, of course, the relations between England and Scotland were so unsatisfactorily defined, and even the boundaries between the English and Scotch realms, and between English and Scotch populations, were so indiscriminate, that the changes in the policy of a man like Robert Bruce are not difficult to understand. Bruce took a decisive course at last, and put himself at the head of Scottish resistance to England's overruling power. Bruce asserted his own right to the throne of Scotland, and was crowned King at Scone. The English Army entered Scotland in the reign of Edward II., and Bruce was defeated more than once. He had to take refuge on the north coast of Ireland, but afterwards returned to his own country, organised a new army, and, after the death of Edward I., in 1307, succeeded in driving the English forces out of most parts of Scotland.

The Battle of Bannockburn. On June 24th, Bruce encountered the English Army under Edward II. at the memorable battle of Bannockburn. The English Army is said to have amounted to 100,000 men; but Bruce, with an army of less than one-third in number, won a brilliant and complete victory. The military capacity of Bruce had made good preparation for this battle. He had drawn the English on to the spot where he could best confront them with his far inferior forces. He had dug the field with pits, which he carefully covered, and kept his own forces well drawn back. The English Army, who had to cross a broad stream to reach their enemies, fell into the pits, which caused so great confusion that Bruce and his soldiers were able to turn the defeat into a complete disaster. King Edward narrowly escaped with his life from the battlefield, and some 50,000 of his soldiers—at least half his army—were either killed or taken prisoners.

In 1317, Robert Bruce crossed to Ireland to assist his brother Edward, who had been engaged like him in the struggle for Scottish independence, and was invited by the chieftains of Ulster, the Northern, or Scottish province of Ireland, to accept the Irish Crown. He was crowned King of Ireland in 1316, and maintained his resistance to the English forces until his death on an Irish battlefield in 1318. The struggle between Robert Bruce and the English went on, after the battle of Bannockburn, until the Truce of 1323. On the accession of Edward III., in 1327, the Scotch invaded the northern counties of England, and it became evident to the English king that England's resistance to the national uprising of Scotland could no longer be maintained with any hope of success. The Treaty of Northampton, in 1328, brought the war to a close by England's recognising the independence of Scotland, and

the right of Robert Bruce to that throne which he had won by the force of his armies and by the indomitable devotion of his countrymen.

The End of Robert Bruce. Robert Bruce did not reign long. He died, in 1329, at Cardross Castle, on the Firth of Clyde, at the age of 54. To him life had indeed been worth living, for he had assured the independence of his country at a time when Scotland could not have counted on any endurable condition except by the terms of national independence. Bruce's body was buried in the Abbey of Dunfermline, and, according to his own desire, his heart was to be carried to Palestine and laid to rest within the sacred city of Jerusalem. The bearer of the heart, Sir James Douglas, commonly called the Black Douglas from his dark complexion, was one of Robert Bruce's most brilliant officers in the struggle for Scotland's independence. Douglas was killed in Andalusia on his way to the Holy Land in an attack made on him and his party by the Moors, and the heart of Bruce was brought back to Scotland and laid to rest in Melrose Abbey.

The latter part of Edward II.'s reign was marked by many calamities. There were risings in Wales and in Ireland as well as in Scotland, and there were seasons of famine and of plague. There were struggles against his rule even in England. Edward's last invasion of Scotland led to his having to accept the Truce of 1323. Then came a quarrel with Charles IV. of France, the brother of Edward's wife Isabella, who detested her husband, and actually turned against him under the influence of one of his disaffected nobles. Edward was made prisoner by this band of titled rebels against his power, and compelled to resign the crown in favour of his son Edward. But his resignation of the crown did not save his life, for he was murdered in Berkeley Castle on September 21st, 1327.

Edward III. Edward II. was succeeded by his son, Edward III. The reign of the young King began under the most unpromising and even appalling conditions. He came in for the succession of a still enduring hostility between England and Scotland, and for constant disturbances in Ireland and in Wales. At home there was widespread discontent caused by poverty, itself in great measure the result of extravagant expenditure on war, and in the suppression of frequent rebellions at home.

Edward III. was proclaimed King at the very time when his father was held prisoner in Kenilworth Castle, and the young King for a while refused to accept the throne offered to him without the sanction of his father. The supporters of the Queen and her party then went through a sham ceremonial to obtain the King's consent, and the hesitating son was prevailed upon to accept his new position. The young King was for the time a mere instrument in the hands of his mother and her supporters. He was still but a boy of fourteen, and a number of peers and bishops were appointed to act as a council of regency, to be the advisers and guardians of the sovereign during his minority. Most of the members of this council were under the influence of the King's mother and her favourite, Mortimer, and Queen Isabella was therefore enabled to exert her own authority over the government of the realm without regard for the intentions of Parliament, which was already beginning to claim its rights as the representative of national opinion.

Troubles again arose with Scotland. After the death of Robert Bruce, Edward Baliol claimed the Scottish throne, and Edward III. came to his assistance and inflicted defeats on the opposing Scots, but could not bring them to submission. These disputes between England and Scotland were still going on when King Edward allowed himself to be drawn into hostility with France. The French king, Charles IV., died without leaving a son, and the nearest heir to the throne, Philip of Valois, was proclaimed sovereign as Philip VI.

Battles of Crecy and Poictiers. Edward claimed the crown on the ground that his mother was a sister of the dead sovereign, and although the law of France did not allow a woman to succeed to the throne, Edward maintained that a woman's son might be the direct and lawful successor. This led to a war with France, and to Edward's invasion of that country. His first attempt was unsuccessful; but in 1346, accompanied by his eldest son, the famous Black Prince, he defeated the French in the memorable battle of Crecy. Not long after, the Black Prince accomplished the great victory of Poictiers, where the King of France, John II., son of Philip VI., who had died before the dispute about his right to the throne had ended, was taken prisoner. A peace was concluded, but as one of the conditions of King John's release from captivity was that he should pay a large ransom, which he found himself unable to do, the French King gave himself back to his enemies, and was taken to London, where he died in 1364.

The Scottish king, David II., had made a secret treaty with Edward by virtue of which the Scottish kingdom was to be handed over to the English over-rule if David should die without a son. Thus, neither in Scotland nor in France did Edward secure any of the advantages for which he had fought so hard, and for which in France he had won two of the most brilliant victories known to history.

Trouble at Home. Edward with all his sagacity did not seem to be able to appreciate the fact that success on the battlefield and the infliction of defeat on foreign enemies will not always reconcile a sovereign's own people to the disturbance of commerce and trade, the discouragement of all profitable work, and the hideous spectacle of gaunt national poverty, brought about by the pursuit of the conquest of territory and the glitter of military fame. Edward began to find the work of government beyond his strength. The finances of the State were threatened with exhaustion, and civil government was falling into what seemed hopeless collapse. Edward became entangled in frequent disputes with his Parliament, and meanwhile gave himself up to demoralising influences, and made less and less effort to restore the

prosperity of the state. His third son, John of Gaunt, was left to look after the business of government. His eldest son, Edward the Black Prince, who had become an open opponent of his father's do-nothing policy, died on June 8th, 1376. The Black Prince, who is said to have derived that name from the colour of his armour, had distinguished himself in other campaigns as well as in the victories of Crecy and Poictiers. He is said to have acted with merciless severity in some of his conquests of captured cities; but generous and merciful dealings with the inhabitants of cities that had made a stubborn resistance was not common among the conquerors of those times.

The life of Edward III. did not last long after that of his eldest and most famous son. He died on June 21st, 1377.

The Birth of English Literature. Edward's reign will always be famous for its victories on the battlefields of France, but it will find a still higher title to enduring recollection in the fact that it saw the birth of genuine English literature [see LITERATURE]. Geoffrey Chaucer, the first of the great English poets, had written some of his greatest poems while King Edward was still living. He was the son of a tavern-keeper in London, and the date of his birth is not certain. Some writers give it as 1328, but the accounts which seem more authentic give it as 1340. In his youth he became a page in the household of the Duke of Clarence, and was afterwards raised to the services of the Royal Family. He served during one of the campaigns in France, was taken prisoner in Brittany, but was soon ransomed, the English sovereign contributing a part of the amount demanded. The King afterwards granted him a pension. He was sent abroad on several missions into Italy, Flanders, and France, and also held the post of Comptroller of the Customs in the Port of London.

Gower and Wycliff. Another poet who belongs to Chaucer's time, James Gower, was a personal friend of Chaucer's, but the fame of Gower is not so closely associated as that of Chaucer with the development of English literature, because some of Gower's poems are written in Latin and some in French, and the lesser number in English. Up to that time the English tongue had not yet become thoroughly recognised by Englishmen as the most suitable medium for poetry. The love of poetry was still supposed to be the attribute only of scholars, and a man gifted with a genius for the telling of tales or for the teaching of noble sentiments in verse believed himself more likely to find an appreciative audience by addressing his poems to those who could understand them in Latin or even in French. Chaucer spoke to his countrymen in their own language, and his successful enterprise made a new era in the intellectual development of his country.

James Wycliff was a great preacher, reformer and writer. He was bold and even daring in his efforts to exalt the religious teaching of his order and of the age, and made himself especially hostile to the Papal Government of Rome. Wycliff was one of the forerunners of that great change which took place in the history of this country when England as a State withdrew from the spiritual domain of the Church of Rome. We mention him especially in association with this period because the earliest of his works were written in Latin, and it was only when he desired to appeal to the English people at large that he addressed them in their own language. He became the first great prose writer in the English tongue. Wycliff died on December 31st, 1384.

The Fame of a Reign. King Edward III. was not much devoted to literary culture, although he proved a generous patron of authors in prose and poetry. His reign did much for the development of England's constitutional system, for representative government in a parliamentary assembly, for civic and local rule throughout all parts of the country, and for better administration of justice through courts of law. The historic fame of the reign, however, will be associated more closely with the victories of English armies over the French than with any other events. The struggle with France begun by Edward III. is known as the Hundred Years War, and the influence of that century of battlefield rivalry kept alive a spirit of hostility between England and France which made them enemies down to a period not far distant from our own. In the days of Edward III. the incessant warrings between neighbouring states were to be excused or explained to a great degree by the undetermined limits and conditions of nationalities; by the fact that the sovereigns of England still held some regions in France, that the sovereigns of France still owned some parts of Italy, Austria, and other countries, that the monarch of one state occasionally claimed the right of succession to the throne of another, and that the world in general did not yet recognise the importance of nationality in the domestic government and foreign relations of states.

Establishment of the Order of the Garter. We must not allow Edward III. to pass from this history without recording that he established the Order of the Garter, which has been one of the most distinguished and distinguishing marks of the sovereign's favour from that time forward. Edward had, it is said, originally intended to revive the Round Table of King Arthur, and proposed to establish tournaments, to which knights from all foreign countries were to be invited to celebrate the institution. After one of his great victories on French battlefields, generally understood to be that of Crecy, King Edward created a new order, and, according to some historians, called it the Order of the Garter because he made use of his garter as the signal for the opening of the battle. Other accounts say that the new institution, which was founded somewhere about April, 1344—different dates are given also—was originally called the Order of St. George, and only in the reign of Edward VI. was called the Order of the Garter.

Continued

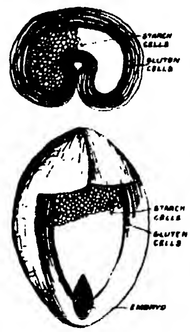
Group 16
FOOD SUPPLY
1
Following on HOUSEKEEPING page 2967

MILLS AND MILLING

Milling Machinery. Cleaning and Conditioning. The Roller Mill. Flour, Middlings, and Semolina. Prepared and Predigested Cereals

By CLAYTON BEADLE and HENRY P. STEVENS

THOUGH at first primitive man used his teeth as the grinders for his grain, we come across references to grinding implements and mills in very early records. Flat stones consisting of a fixed stone and upper stone or runner are still to be found to-day, but are being rapidly replaced by the modern machinery we are about to describe.



1. SECTIONS OF A GRAIN OF WHEAT

The Wheat Grain. As will be seen from the diagram [1], the wheat grain consists of an oval shell composed of several layers surrounding a mass of starch cells, and the object of the miller is to separate the starch cells as completely as possible from the outer shells (bran and other residue, termed "offals").

All milling machinery is devised with the object of producing the largest possible proportion of pure flour, the "broadest" bran, and the cleanest "offals." The reason for this is obvious—flour is supplied for human consumption, and commands the highest price, whereas the bran and offals are of inferior value, and only suitable for cattle food and similar purposes, although brown bread contains a certain proportion of bran. Further, with modern machinery, the separation of flour and offals is best attained by scraping the kernel of the grain out of its covering with as little damage as possible to the former. This yields broad bran—that is, bran in large pieces.

The Roller System. In the modern method, where the grain is passed between several pairs of rollers, the separation of the offals takes place *during* the grinding instead of afterwards. The wheat also undergoes a very thorough preliminary treatment in which it is separated from foreign ingredients and thoroughly cleaned before milling. The grinding is effected in the first place by fluted steel or "chilled iron" rolls, between which the material passes, so that the individual grains are cut or slit as thoroughly as possible, without crushing more of the kernel than is necessary. Much of the bran and offals can be removed in this manner before the kernel is finally reduced to flour. Speaking generally, the product is treated to separate the bran from meal, after passage through each pair of rollers. The meal has further to be separated into flour and unreduced "endosperm" from the interior of the grain by first crushing between smooth rolls. After each treatment, the products pass to machines for separation into flour and "semolina," or "middlings." The latter are again reduced by passage between smooth rolls and dressing machines, yielding for instance, in the case of "coarse" semolina, flour on the one hand, and "sharps," or "thirds," on the other. The principle involved in these operations will be better understood by reference to the diagrammatic table on the next page.

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2. Wheat mixture (Manitoba, Russian, and La Plata) uncleaned 3. Cleaned and conditioned wheat 4. Cockle and broken wheat extracted by indented cylinders 5. Extracted oats and barley

General Principles. The ideal aimed at in milling machinery is to strip off the covering of the kernel and remove the bran before reducing the interior of the grain. It will be understood that this latter requires further treatment, as it is made up of numbers of tiny cubes containing the flour enclosed in a fine skin. These must be reduced before separation into flour and middlings, or semolina, can take place.

So perfect are the modern systems of roller milling, as represented by the Robinson system and the practices of other British firms, that there is less than 1 per cent. waste in treating the wheat

when once it is cleaned and conditioned. The yields may be given approximately as: flour 70 to 72 per cent; offals (sharps, pollard, and bran), 27 to 29 per cent.; waste, 1 per cent.

Explanation of Terms. The finest ground product is the *flour;* the particles of "*dunst*" are a trifle coarser; *middlings* coarser still, and *semolina* the coarsest of all. The three latter, of course, are ultimately reduced to the first—*viz.*, flour.

"Sharps" are the finest particles of the shell or outer coating of the grain separated in the final stages of milling. They correspond in size to middlings. *Pollard* is composed of larger pieces, and the *bran* represents pieces of husk but little damaged by passage through the fluted rolls.

Milling Machinery. We will now proceed to describe in detail the construction and method of operating the most modern form of plant for milling wheat. After this we will go through a mill and see the course which the wheat, and then the offals, flour, and bran, travel through the different machines on their way from the "silos" or bins, where the raw material is stored, to the "sacking spouts" and patent packers where the finished products are caught off.


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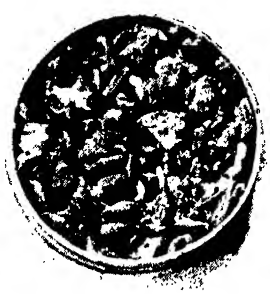
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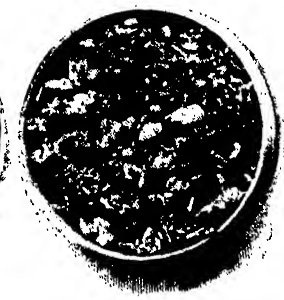
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6. Stones, etc., extracted from wheat in the process of washing **7.** Screenings extracted from wheat by aspiration **8** and **9.** Stock after passing through 1st and 2nd break rolls respectively

Cleaning. This entails quite a number of separate operations, the first of which is carried out in a wheat separator and scourer [**11**], in which the wheat is separated from coarser impurities, such as sticks, stones, and large refuse generally, and scoured to free it from adhering particles of dirt, and break up little balls of earth, always found to a larger or smaller extent in sacked corn. Fig. **10** illustrates the action of this machine. The uncleaned grain falls into a separating sieve which is kept constantly on the jog. The efficiency of the separator is considerably augmented by the currents of air sucked through the machine by the fan situated above. Air is drawn through the stream of uncleaned grain as it passes on to the sieve, and through the cleaned grain as it leaves the machine, carrying impurities [**7**] with it. After leaving the sieve the material is conducted to the interior of a perforated steel cylinder, where it is scoured by rapidly revolving beaters, which cause the grains to rub against themselves so that the loosened dirt and dust pass through the perforations in the cylinder, and the cleaned grain finds its way out at the other end.

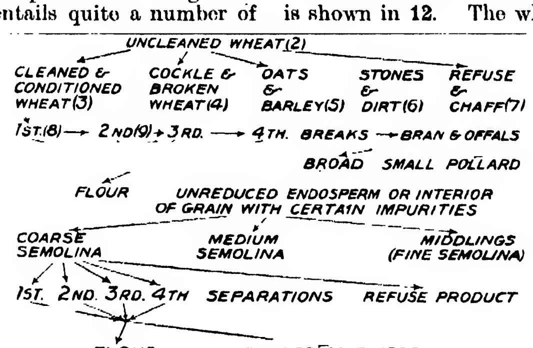
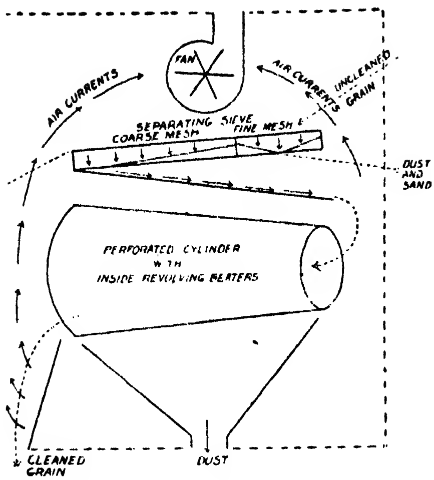


DIAGRAM OF THE PROGRESS OF WHEAT TO FLOUR
(The bracketed figures refer to the illustrations)

Washing. It is also necessary to wash the grain with water to free it from stones [**6**] and dirt, which could otherwise only be got rid of by very prolonged action in the scourer, where such drastic treatment would probably damage the outer skin. In soft wheats, such as "Ghirkas" and "Platas," the immersion in water must not be prolonged, and the moisture should be rapidly drained off.

The washing and subsequent drying, or conditioning, in some cases toughen the bran, so that it is more easily detached in large pieces, and hard wheats require moistening, not only to enable them to mill better, but because the flour produced from them is better in colour.

Robinson's wheat washer, stoner, and rinser is shown in **12**. The wheat as it enters at the right-hand top side of the machine is met by a jet of water and carried round with it by a revolving paddle which effectually immerses it. The wheat and water flow down an inclined plane, at the bottom of which they meet another stream of water moving upwards, adjusted to such a pressure that the stones, being heavier, sink, while the grain is carried over into another tank, whence it is lifted by the "worm" seen on the top left-hand side of the machine. Streams of water play on the grain as it is being removed by the draining worm. The spent water is carried away through the perforations after thoroughly rinsing the grain.



10. DIAGRAM OF SEPARATOR AND SCOURER

The Whizzer. To rapidly remove the adhering water from the grain, the latter is conducted to a "whizzer," which consists of a revolving drum to which lifting plates are fixed. These are short, projecting pieces of metal placed diagonally, so that the wheat fed in at the bottom is lifted up and carried to the top of the cylinder. Meanwhile a strong draught blows through the grain, and, by the centrifugal action, the water is thrown off and driven through a perforated casing surrounding the drum. The wheat is, however, by no means dry, and much of the superfluous moisture has still to be got rid of.

Drying and Conditioning. Wheat is not required in a "bone dry" state for milling; a certain percentage of moisture is beneficial and even necessary, and the machine we are about to describe can be adjusted so that the grains retain the right proportion. This is what is meant by conditioning.

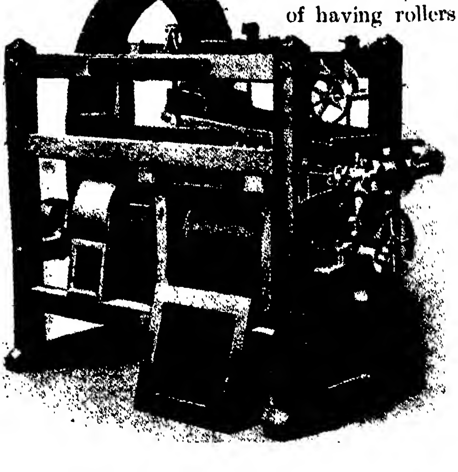
Mallinson's machine is shown in section [13]. It consists of two hoppers, A and D, into one of which, A, the grain passes from the whizzer, whence it descends between the wall or casings, BB, being checked in its fall and turned over at intervals by pieces of metal projecting inwards, and leaves the casing at C. Inside the right-hand casing are a number of vertical steam pipes, one of which is seen in the drawing. At the bottom is a steam chest and the air entering at E is heated by passing between steam pipes on its way to the hot-air chamber, F, and is then drawn by a fan through the wheat in the direction shown by the arrows. The grain which leaves at C is elevated and deposited in the hopper D, whence it passes down the left-hand casing MM. The material is cooled before leaving at H by a current of cold air entering by the channel K.

The heat given off by the steam pipes inside the casing below A causes the wheat to sweat, and brings the moisture to the surface, leaving the interior of the grain in an excellent condition for milling, and at the same time toughening the skin so that the bran can be stripped off in large flakes. Steam pipes are omitted from the casing MM, as experience has shown that gradual cooling is an essential factor in successful conditioning of wheat.

Brushing. To remove the remaining dirt and dust, the grain is treated in a wheat brush. The action of this machine will be understood by reference to the diagram [15]. Its construction is similar to that of the scourer [10 and 11]. The wheat is led into a perforated steel cylinder, containing a drum fitted with rapidly revolving brushes which brush the wheat and remove any smut or dirt loosened by the action of the washing and drying machine. The dust falls through the perforations in the cylinder.

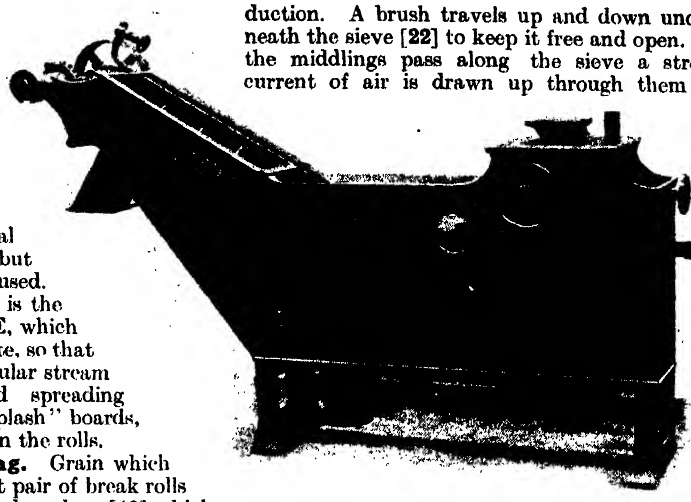
Extracting Cockle. Wheat always contains a certain proportion of foreign seeds and cockle [4], which are removed by cylinders of special construction [14]. The cockle cylinder consists of a slowly-revolving drum, the inner surface of which is formed by a zinc plate drilled with a great number of small holes or indentations of peculiar shape [16], in some cases as many as 30,000 to the square metre. As the cylinder revolves it gathers into the indentations the cockle and small foreign seeds. When they reach a certain position they fall off again into a conveyer, or trough suspended in the lower half of the cylinder, which carries them to the outlet. The clean grains, now ready for milling, pass out at the end of the cylinder, and are elevated to clean wheat bins.

The Roller Mill. The machine in which the actual grinding takes place [17] is built with two pairs of rollers placed diagonally, although many machines have the rolls placed horizontally. The diagonal arrangement, however, has certain advantages and is described here [19] The rolls make the same number of revolutions per minute, but as one roll, A, is smaller than the other, B, the necessary differential is obtained at the point of contact, and a shearing effect produced in this manner, instead of having rollers of



11. SEPARATOR AND SCOURER
(T. Robinson & Sons, Ltd., Rochdale)

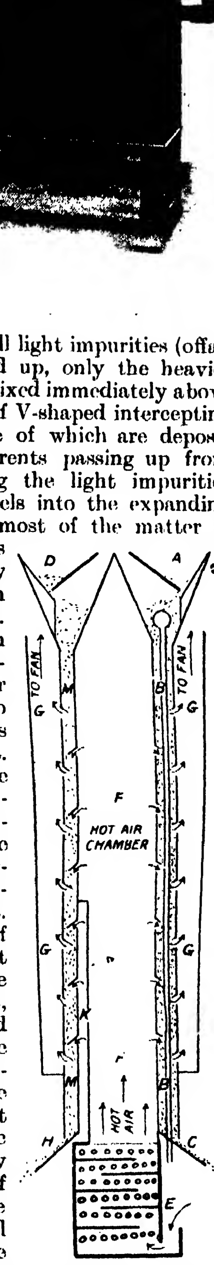
the same diameter with gearing to different speeds. The rolls are either fluted or smooth. The fluted or "break" rolls are used for splitting the outer covering of the grain, and smooth rolls for the final stages of grinding. Above the rolls is a shaker feed, which is well adapted to material treated with break rolls, but roller feeds can also be used. Underneath the tray, DD, is the eccentric shaft and block E, which causes the former to vibrate, so that the material passes in a regular stream underneath the "hinged spreading boards," FF, on to the "splash" boards, GG, which guide it between the rolls.



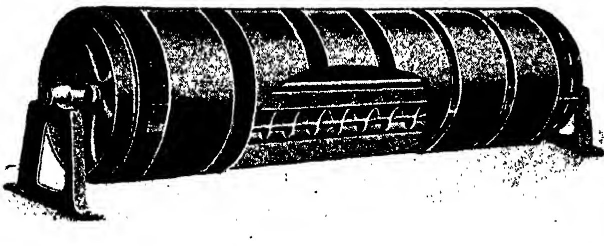
Sifting and Dressing. Grain which has passed through the first pair of break rolls [8] is treated in a sifter and scalper [18] which separates the material with the aid of rotary sieves suspended almost vertically. This separation is of a preliminary nature; the real dressing or sifting of the flour is effected in a centrifugal dressing machine [20] which consists of a skeleton cylinder, A, covered with silk gauze of fine mesh fixed horizontally and rotating slowly [21]. It contains a number of beaters, B, which revolve rapidly. The material to be treated is fed into the cylinder, and by the action of the beaters is forced against the gauze, whereby the flour is "dressed" or sifted through. Underneath the cylinder is a trough with a conveyer, C, which removes the flour while the unsifted material passes over the end or "tail" of the cylinder for further treatment. These machines are often provided with two conveyers lying side by side in separate troughs (C and D). There are a number of hinged covers which shut in either conveyer so that the flour finds its way into one only, as C in 21. If now one half of A be covered with finer gauze than the other, it will let through finer flour, which will collect in the trough open beneath it, so that with the necessary adjustment finer flour will be delivered by one conveyer and a coarser grade by the other. By suitable arrangement of "cut offs" the flour may be graded into different qualities in one machine. We should mention that over the gauze-covered cylinder A are brushes, to keep the perforations in the silk from getting clogged.

Purification of Middlings and Semolina. Middlings consist of wheat particles reduced to a certain extent by passage through break rolls, while semolina is practically the same thing, except that the particles are coarser.

The machine known as a "purifier" effects a sort of double separation on either of these materials as its action is twofold. In the first place, it consists of a long flat sieve kept vibrating by the action of an eccentric [23]. The sieve is divided into four parts, each of which is covered with gauze of different mesh. The tailings, consisting of particles too large to pass through the sieve, are taken to the rolls for further reduction. A brush travels up and down underneath the sieve [22] to keep it free and open. As the middlings pass along the sieve a strong current of air is drawn up through them by means of a fan, so that all light impurities (offal) are lifted out and carried up, only the heavier portions being sieved. Fixed immediately above the sieve are a number of V-shaped intercepting channels, on either side of which are deposit platforms; the air currents passing up from the sieve and carrying the light impurities pass between the channels into the expanding chamber above, where most of the matter is released and falls. This is shown diagrammatically in 24—a vertical section of the expanding chamber. The peculiar construction of the intercepting chamber causes the greater part of the material to deposit on the platforms on either side of it. Should any material be carried further, it is deposited in a second expanding chamber above the first, and the air currents pass to the fan practically free from dust. The vibrating action of the sieve causes the light impurities (offal) to move down towards an outlet, as sieve, platforms, and intercepting channels are fixed at a slight inclination. The deposit on the upper platform is swept down by an automatic "brush cleaner," and by a suitable arrangement of worms and channels the combined deposits of offal are removed from the machine. The machine is also provided with cut-off



13. SECTION OF DRYER AND CONDITIONER



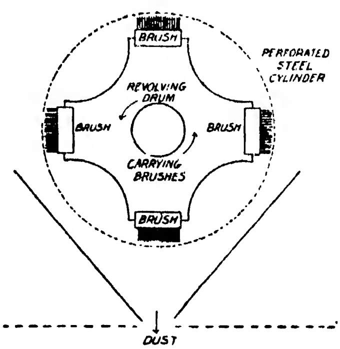
14. COCKLE CYLINDER (T. Robinson & Sons, Ltd.)

boards and a double worm at the bottom, so that those portions which pass through the different mesh sieves or any combination of them may be kept separate as desired.

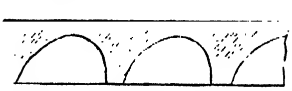
A Working Mill. We shall now indicate how these machines contribute individually and collectively to the separation of flour from wheat.

Fig. 28 shows a model of a small mill of about two sacks per hour capacity, and 26 is a diagrammatic section of this mill, in which the flow of the material from one machine to the next through the mill is indicated by arrows.

On the left hand is the wheat cleaning and conditioning department, and on the right hand the actual flour milling. In the former the grain is elevated to the top floor, and passes straight through the various machines in the order in which we have described them.



15. WHEAT BRUSH



16. SECTION OF INDENTED PLATE

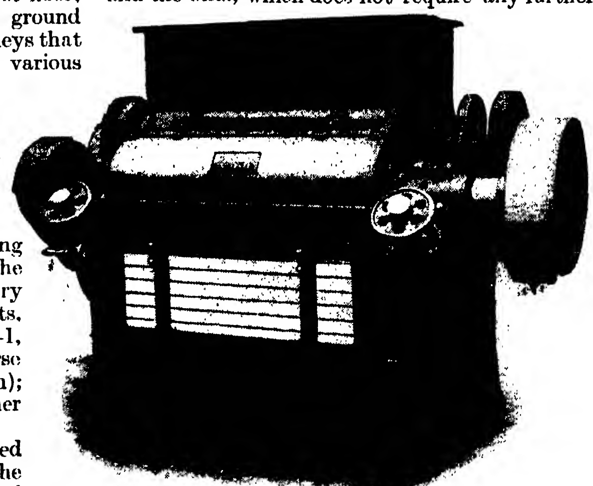
The Milling Department. In the next department the sieve and scalper [18], as well as the grading and dressing machines [20], are on the top floor. The second floor is taken up by the purifiers, and the roller mills occupy the first floor, the first three pairs being fluted. The ground floor is reserved for the shafting and pulleys that transmit the motive power to the various machines on the floors above.

Let us start with the cleaned and conditioned wheat [3] as it leaves the clean wheat bin, whence it is spouted to the first pair of fluted rolls just below. The flutings of these rolls are coarse, and the rolls are comparatively wide apart, so that they crack the grain, partially setting free the kernel. This material [8] from the first "break" is elevated to the rotary sifter, which separates it into three parts, according to the size of the particles—1, the coarse wheat particles; 2, coarse semolina (coarse particles of the endosperm); 3, fine middlings and flour (still finer particles).

The coarse wheat particles are spouted to the second pair of break rolls on the first floor. These rolls are set closer, and the flutings are not so coarse as in the first pair; their action is to release more semolina, and the resulting products [9] are elevated to the dressing machine on the top floor for further separation. The coarsest particles (overtails) from this machine consist mostly of large pieces of bran which retain but little floury matter, and are taken to the third pair of break rolls, which are more finely fluted than either the first or second pair. By their action the remaining particles of flour are scraped from the pieces of bran, and separated by elevating to the centrifugal dressing machine [20] on the top floor.

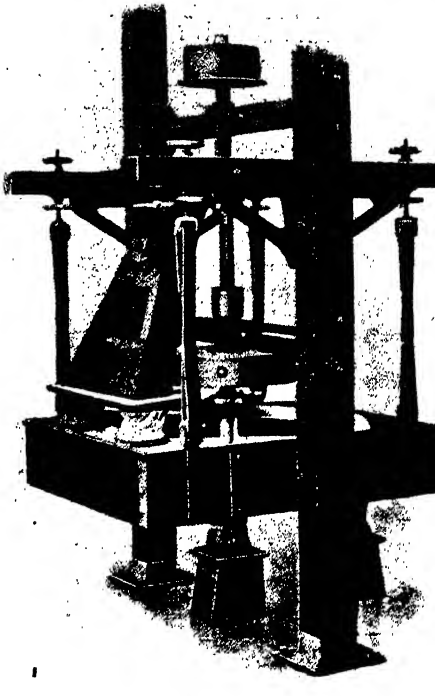
We have now followed the coarse wheat particles through the three pairs of rolls, leaving the grain in various stages of reduction (semolina and middlings), from which the greater part of the bran has been separated. In larger mills we find more than three pairs of break rolls, but the principle involved remains the same.

Treatment of Semolina. Having traced the course of the first product—the coarse wheat particles, let us now take up the second—the coarse semolina. It will be remembered that we left this at the rotary sifter, where it was separated from products one and three; it is spouted to No. 1 purifier on the second floor. The purified semolina which has passed through the sieve of this machine goes to the first pair of smooth rolls underneath for further reduction. The tailings of the sieve go back to the fluted rolls, and the offal, which does not require any further



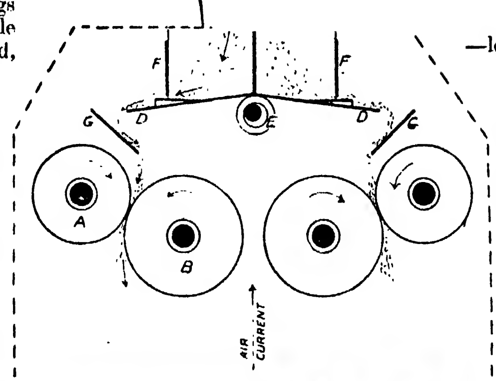
17. DIAGONAL ROLLER MILL (T. Robinson & Sons, Ltd.)

treatment, is carried away in a third direction. It is not possible to demonstrate the course of all these products in the plan [26], so that we have indicated by arrows the path of the main product, the purified semolina, only. After passing the smooth rolls, it is elevated to a centrifugal dressing machine on the top floor, where the flour is "dressed" out, and the tailings pass to the separating sieve on the second floor. Here the germ is eliminated, and the unreduced portions pass to another pair of smooth rollers, to be again elevated to the top floor, and delivered into a dressing machine to separate the flour. In each case where flour is extracted by the dressing machines it passes away by the conveyer underneath to the sacking apparatus. The overtails are again reduced by roller mills, and then dressed till all the flour is extracted, leaving nothing but finished offal.



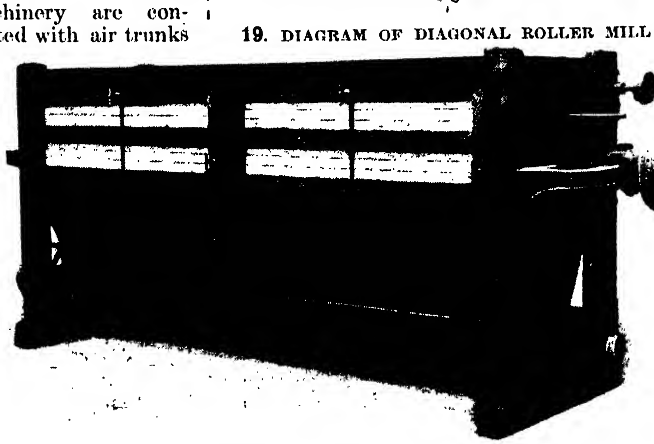
Treatment of Middlings. The third product, the fine middlings and flour, are treated in a centrifugal dressing machine to separate the flour from the middlings, the latter then passing to purifier No. 2 on the second floor. The further treatment of the products resembles the process we have already described in speaking of No. 1 purifier. The overtails from both pass to fluted rolls, to be worked up with coarse wheat particles, while that portion which passes through the sieves goes to smooth rolls for further reduction. In both cases, after repeated grindings and dressings the whole of the flour is removed, and nothing remains but finished offal—sharps, or thirds.

In the grinding and repeated treatment to which such finely-divided material is subjected, much dust and fine particles would escape into the atmosphere if special precautions were not taken. The rollers and other machinery are connected with air trunks—long channels or elongated boxes—through which air is drawn by a fan. This exhaust carries the dust to a dust collector, a large cylindrical box within which the air currents course, striking the walls and depositing the dust on the sides and bottom, where it collects, and can be removed. The air current may also have some effect in ærating the flour and help to keep the rolls cool.

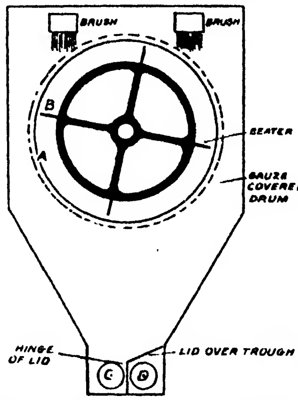


19. DIAGRAM OF DIAGONAL ROLLER MILL

We have outlined the arrangements in a small mill of two sacks per hour, but in larger mills these would be considerably amplified, and, generally speaking, more complicated. With more machines—say, for instance, five sets of break rolls instead of three—the reduction and separation would be more gradual, and consequently more complete. The cut-offs may also be made greater use of so as to separate the products from each machine (purifier or dresser) into two or more

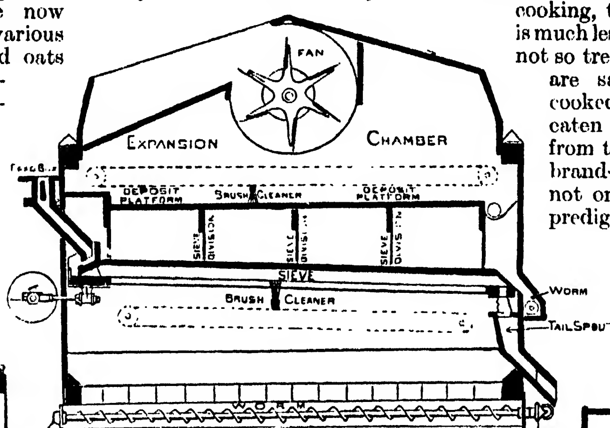

20. CENTRIFUGAL DRESSING MACHINE (T. Robinson & Sons, Ltd.)

portions, each of which may be kept separate for further treatment. Take, for instance, the cylindrical sieve of a dresser [27]. All flour that passes through the gauze of fine mesh, Nos. 11 and 12, is taken away to the flour sacks as finished product, but the cut-off material which passes through the coarser No. 5 mesh gauze would in a large mill be kept apart and treated separately from the overtails. It may also be necessary to modify the treatment from time to time according to the class of material dealt with, so that it is not possible to give a standard to which all milling processes will conform. The examples we have chosen are, however, as nearly as possible typical of an up-to-date installation.

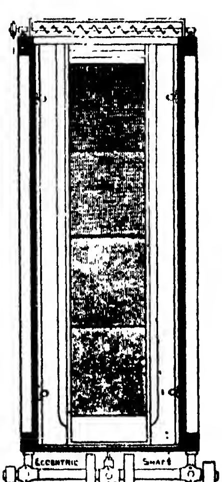


21. SECTION OF CENTRIFUGAL DRESSING MACHINE

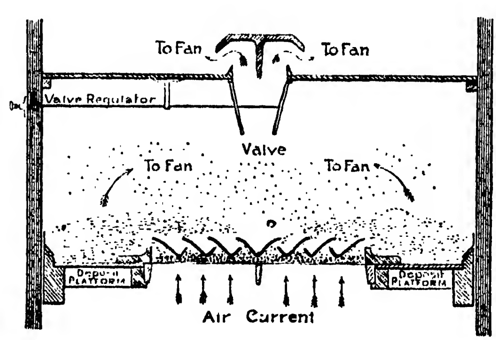
Cereals Other than Wheat. In conclusion, we would call attention to the ever-increasing special treatment of various grains in the preparation of patent, breakfast, and other foods. Oats in the form of porridge made by boiling the coarsely ground cereal form an important food product in this country, but are now being replaced by various brands of prepared oats obtained by steaming the grains, crushing them between rollers, and then drying them. Such treatment in the preparation of so-called "rolled oats" ruptures the cell walls and partially cooks the grain, so that it requires less cooking for the table and is more palatable than untreated oatmeal. The majority of the widely-advertised breakfast foods are produced in much the same manner as wheat flour as regards the first stages. As in the milling of wheat, the first treatment consists in cleansing the grains, which, to be thoroughly cleansed, should be put through the scourer, separator, washer, stoner, and brusher already described. The clean grain then passes through coarsely-fluted rolls to remove the outer coat, but there is no need to make a complete separation of the interior portions of the grain from the bran as in the production of white flour. Sometimes the grains are first soaked in a weak alkaline solution to aid the removal of the outer skin, but in every case the grains are rolled after removal of the coarse bran. In this state the products require a good deal of cooking before they are ready to be eaten. "With other brands the treatment is carried much further. Some of them are partially cooked, and, while still requiring some cooking, the time of cooking is much less than for materials not so treated. Some brands are said to be wholly cooked, and ready to be eaten as they are taken from the package. Some brands are claimed to be not only cooked but also predigested. Further than this it is hardly possible to go!" (Milner.) The products may be partially cooked by steam heating



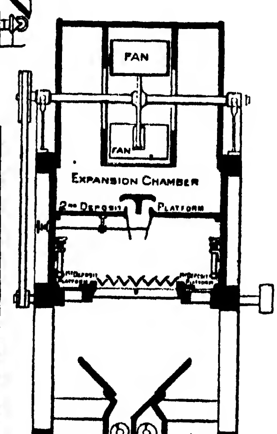
22. LONGITUDINAL SECTION OF PURIFIER
(T. Robinson & Sons, Ltd.)



23. PLAN OF PURIFIER SIEVE

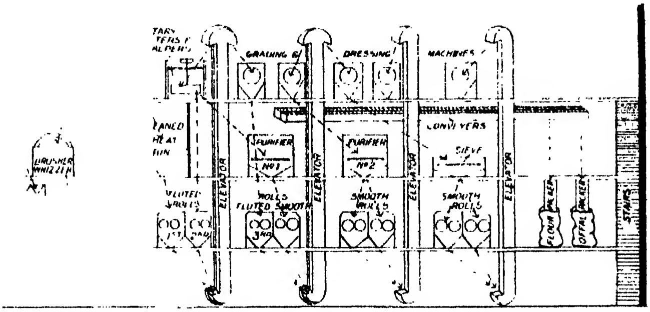


24. SECTION SHOWING CHANNELS AND EXPANSION CHAMBER OF PURIFIER



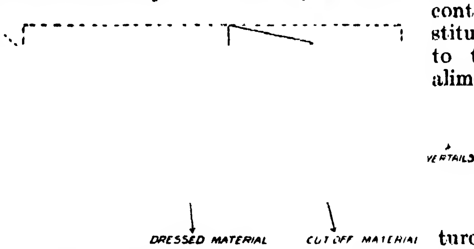
25. CROSS SECTION OF PURIFIER

as in the case of "rolled oats," and in some cases by carrying the cooking further, and then rolling as in the case of the thin "flake cereals." In other cases, again, the grains are roasted, or first moistened and then roasted, so that on crushing them granular products are produced resembling dried crumbs. The shredded preparations are obtained by working the softened grains in suitable machinery.



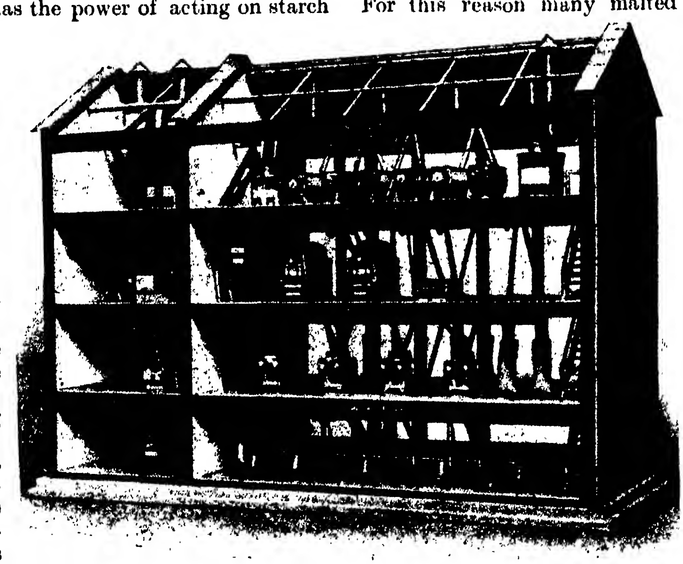
26. DIAGRAM OF A FLOUR MILL, SHOWING AUTOMATIC FLOW OF MATERIAL THROUGH THE MACHINES

Predigested Foods. To realise the aim and object of the treatment to which these so-called predigested or malted foods are subjected we must remember that the starch of which they are mainly composed [see STARCH] is itself an insoluble substance, and is not available for nutrition until it has been acted upon by certain ferments present in the alimentary canal. Thus the pancreas secretes a fluid which has the power of acting on starch with the formation of soluble substances (sugars), which then by further action are absorbed into the system. This property of acting on (hydrolysing) starch is possessed by other substances besides those found in the digestive tract. In germinating barley there is, for instance, a peculiar ferment (enzyme) termed diastase, which is so far similar in its behaviour to the action of the pancreatic juice that it converts the starch into a sugar (maltose). This process, however, does not use up the diastase, a small quantity of which is capable of transforming large quantities of starch into maltose. If crushed cereals containing starch be macerated with a small quantity of ground malt (barley arrested in the early stages of germination), and the mass be kept warmed, the ferment will convert a part of the starch into sugar (maltose). The dried mass will then contain part of its constituents in a shape similar to that obtaining in the alimentary canal in the first stages of digestion, and may therefore be regarded as in a partially digested state.



27. DRESSING MACHINE WITH CUT-OFF PARTITION

In actual manufacture the action of the diastase is not allowed to go on too long as small quantities of by-products would be obtained, giving rise to unpleasant flavours. For this reason many malted or predigested foods contain only a small proportion of their starch in the form of sugar. However that may be, actual feeding trials have shown that these so-called predigested foods have little or no advantage over ordinary wheaten bread in nutritive value in spite of what is frequently claimed for them. It will be found difficult to improve upon the ordinary wheaten bread made from grain which has been carefully cleaned and properly milled.



28. FLOUR MILL ON THE ROBINSON SYSTEM

Milling concluded

Group 10 **ELECTRICITY** **22** Continued from page 3012	# ELECTRIC ACCUMULATORS **The Secondary Cell. Planté's Type. Faure's Type and its Modern Equivalents. The Capacity and Efficiency of Cells. Care of Accumulators**

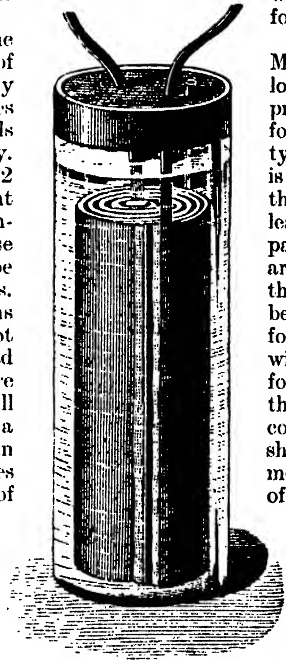
By Professor SILVANUS P. THOMPSON

A DRAWBACK with electricity when used for lighting purposes is that it cannot be stored to anything like the same extent as gas. If the gas generators break down, there is a supply of gas in the gasometers to go on with for some time. With electricity we have, however, a method of storing electric energy, to be correct, and not electricity itself, but the apparatus is so costly and cumbersome that it is not practical to install it to such an extent as to cope with the total demand of a station for any length of time. It is these facts which add force to the remarks made on page 2816 on the subject of the economic generation and the charging for electric energy.

The Secondary Cell. The apparatus used for the storing of electrical energy consists essentially of a voltaic cell [page 462], the plates of which consist of lead or compounds of lead. This makes them heavy. Their electromotive force is about 2 volts, so that for the ordinary light and power circuits of to-day, running at 200 volts, over 100 of these cells are required. Also, they can be used only with continuous currents.

In country-house installations where a little extra expense is not a consideration, and where the load is quite small, storage batteries are put in which will deal with the full demand; but in large stations a battery of such a capacity only can be installed as will *help* the engines and generators during the period of the highest load.

The fundamental principles on which the electric accumulator is based have already been given on page 463. We saw there that when a cell is made of zinc and copper dipping in dilute acid, bubbles are formed on the plates, due to the chemical action of the current, and these bubbles polarise the cell or set up an electromotive force which, opposing that of the cell itself for the time being, renders the cell useless. In 1860, Planté devised a cell of two sheets of lead, which in themselves, of course, gave no electromotive force, but when *charged* from an outside source, an electromotive force counter to the source of supply is set up, due to the negative plate becoming covered with a coating of the brown peroxide of lead, the positive plate at the same time assuming a spongy metallic state, so giving a large amount of surface of high chemical activity. In Planté's original type, he took the two lead strips and rolled them up in a spiral, so that the cell appeared as shown in **210**. The process of forming Planté's accumulator was long, as it had to be charged and discharged carefully many times before it was completely made and ready for use.



210. PLANTÉ'S ACCUMULATOR

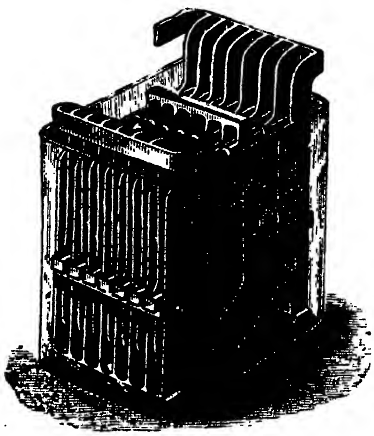
Faure's Pasted Plates. In 1881, Faure modified the Planté accumulator by giving the two lead plates a preliminary coating of *red lead.* When a current is passed through the cell, the red lead is peroxidised at the anode, and reduced in a succession of stages to the spongy lead state at the kathode, and thus a greater thickness of active material is provided which takes a much less time to form, but is mechanically weaker.

Present Day Construction. Most manufacturers have now followed Faure's method, but they provide a better mechanical support for the active material. A modern type of cell, as fitted in a glass box, is shown in **211**. The first process in the construction is the casting of a leaden grid, which is to hold the paste. The patterns of these grids are different with almost every firm, the object in the various designs being to obtain as rigid a support for the mass of paste as is consistent with a minimum amount of metal, for the grid is entirely inactive from the electrical point of view. A common construction of grid is shown in **212**. In the melting of the metal for casting, a small percentage of antimony (a constituent also of type metal) is added to impart rigidity and hardness to the soft lead. No other metal is found to withstand the action of the acid, aluminium having been tried on account of its lightness, and failed.

The paste is made by mixing up the red lead (or *litharge*) with dilute acid in a mixing mill, and it is then worked into the grids as mortar is spread along a line of bricks. The lugs of the plate thus pasted are then cast together in batches, according to the capacity of the cell, and the plates are then erected in temporary glass tanks, and the current for forming them is passed through them continuously. In the course of hours, the one plate becomes gradually reduced to spongy lead, and the other is further oxidised to form the required brown peroxide.

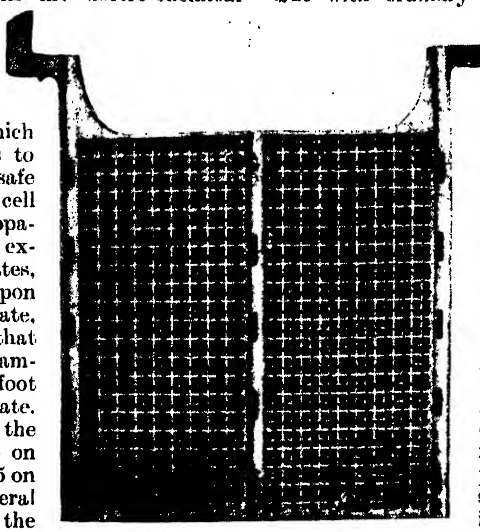
Capacity of Accumulators. What is known as the *capacity* of the cell is measured in ampere-hours. To understand how this

quantity is arrived at, we must know something about the voltage variations which take place. When an accumulator is fully charged, its electromotive force reaches 2·5, and on continuing the charge, gas is freely evolved in fine streams, so that the liquid appears quite milky. On discharging, the voltage rapidly drops to 2·15, and after this it drops quite slowly during the main period of the discharge to about 1·85, at which point it must be considered to be fully exhausted, for should current be taken from it any longer, the electromotive force decreases rapidly to zero, when the cell is practically useless for any further work. The voltage during discharge is shown by the first line in **213**. On charging, as might have been supposed, we must put more energy into the cell than we get out of it, and so, assuming for the purpose of comparison that we are charging with the same current, the voltage which must be applied will be slightly greater than for the corresponding epoch of discharge, and the variations are shown by the second line in the figure.



211. MODERN TYPE OF FAURE'S ACCUMULATOR

Capacity of a Cell. Now there is a limit to the current which we can take from an accumulator. The greatest current it would be possible to take would be by short-circuiting the terminals, but with this the electro-chemical action in the paste is so violent that the paste disintegrates, the plates themselves buckle, and the voltage is speedily reduced to zero, from which it is practically useless to try to raise it. The safe carrying capacity of a cell depends, as will be apparent, chiefly upon the exposed surface of the plates, and to a less extent upon the thickness of the plate, and it has been found that we may take about 7½ amperes for every square foot of positive or negative plate. The time taken for the voltage to fall to 1·85 on discharge or to rise to 2·5 on charge depends on several things, including chiefly the total amount of active material in the cell, and the product of this time and the safe rate of discharge in amperes gives the capacity of the cell in ampere-hours.



212. ACCUMULATOR GRID READY FOR PASTING

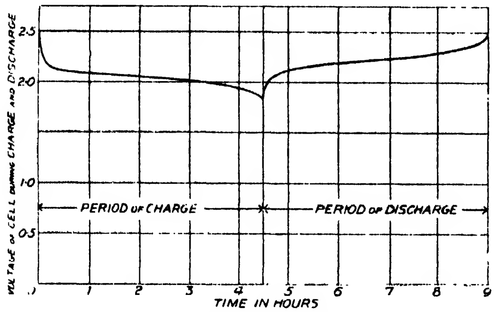
For the sake of comparison, cells are often quoted as so many ampere-hours per lb. of cell. No definite figures can be given for this rating as it varies for each type of cell according to the use to which the cell is to be put. For instance, traction cells are made comparatively light, but have a shorter life, and some cells are made up in lead-lined wooden boxes, while others are enclosed in lead entirely.

Efficiency of Accumulators We do not, of course, get the same amount of energy out of an accumulator as we put into it. When the cell is being worked normally, the efficiency—*i.e.*, the ratio of these two quantities—is between 90 and 95 per cent. When, however, it is discharged at a greater rate, the time taken for the voltage to drop to its minimum value is less than proportionately shorter and a lower efficiency results. These facts are well illustrated by the table on the following page, which deals with an experiment on a well-known make of accumulator. The cell itself was rated at 100 ampere-hours on a 10-hour discharge—that is, it would give 10 amperes for 10 hours, during which time its voltage would have gradually dropped to 1·85.

Deterioration of Accumulators. In course of time, as the accumulator ages, the paste gradually drops out of the plates. This is, of course, expedited by bad usage; but with ordinary usage it will occur. The paste falls to the bottom of the cell, and the suspension of the plates should be such that adjoining positive and negative plates are not short-circuited by a layer of this powder. If the paste come out in lumps, it is likely to get clogged between the plates before reaching the bottom. Especially is this so in traction cells, where everything is made as compact as possible; and to guard against this difficulty the only course is to inspect the cells very frequently. In order to minimise the wasting of paste, many makers have sought to embody the plates in a substance of semi-solid consistency, such as a mixture of water-glass (sodium silicate), with the exciting liquid sulphuric acid, or by using a packing of felt or some such porous substance; but these devices have not been found altogether successful, as the paste will disintegrate, and it is best to allow it a free

passage to the bottom of the cell. A brown or positive plate is found to have only half the life of the grey or the pure lead plate of similar type of construction. This will be easily understood when it is remembered that the negative plate is of pure metal, while the other is still only a powder, which has been rendered solid for the time being by being made up in the form of paste. Further, in connection with this matter, it is the general rule to have an odd number of plates in a cell, the two outside plates of the compound sandwich being negatives.

Supporting the Plates. It is a difficult matter to support in a thorough mechanical



213. VOLTAGE VARIATIONS DURING CHARGE AND DISCHARGE

way a number of heavy lead plates with a minimum allowance for clearance. They must not be allowed to rest on the bottom of their box, because then the fallen paste easily short-circuits the plates at the bottom, nor for the same reason may they be supported upon wooden blocks. The usual method is to cast the grids with side lugs, as shown in **212**, which rest on the top of the boxes as in this case, or, if arranged further down the grid so as to be below the surface of the liquid, on wooden or glass supports, which are fitted against the two sides of the box, and rest on the bottom. The plates themselves are kept apart by insulator rods of glass or ebonite, which are placed between them during erection.

Care of Accumulators. There are perhaps no more delicate pieces of apparatus coming under the care of the electrical engineer than accumulators. To keep them in good condition they should be charged and discharged as regularly as possible, and, if possible, should not be partially charged and then partially discharged, as by treating them in this irregular manner they deteriorate much more quickly. Another important matter is to keep the acid at the correct specific gravity [see PHYSICS]. This varies during the period of charge and discharge, as the chemical actions which go on involve the splitting up and remaking of molecules of water. The correct specific gravity at the full discharge is about 1·175, and at full charge 1·21. Cells should be tested with suitable hydrometers at least once a week to see if these conditions hold, and in cases of high density, which sometimes occur on account of surface evaporation and spraying, should be at once remedied by the addition of distilled water. It will sometimes be found in a number of cells that one or two are not keeping up their voltage. These should be disconnected from the set and given a special charge for about four or five times longer than usual, when it will often be found that they have come up again to the normal state. Most manufacturers issue detailed instructions with their cells and these should be carefully followed. With large batteries, also, it is usual for the makers to contract to keep them in order for a period of years.

Housing of Accumulators. The accumulator house should be shut off from all other parts of the building, and, if possible, should be a distinct erection. The use of metal in its construction should be avoided if possible, the roof principals being made of wooden beam, which can be heavily varnished or coated with some acid-resisting paint. All electric conductors should be treated in the same manner. To stop the spray during charging from spreading throughout the rooms, some makers place cork granules or hollow glass balls on the surface of the liquid; but a more general, although not so effective a remedy, is to rest a glass plate across the supporting lugs at the top of the plates.

Use of Storage Batteries. Several uses of storage batteries have already been mentioned, such as a standby in case of accident or a help in case of excessive demand. The small accumulator is also a handy source for portable use, and many sets are sold for cable testing and field telegraph work in which they have supplemented the older primary batteries. Perhaps the most valuable use of the battery is on traction systems where the load is continually fluctuating in value. These fluctuations do not conduce to the good working of the generators, and so a battery is installed parallel with them, and this takes the large momentary demands, receiving back its energy in turn from the generator in times of a slack demand. This

EXPERIMENT WITH AN ELECTRIC ACCUMULATOR

Hours taken for cell to discharge.	Current rate of discharge in amperes.	Calculated capacity at this rate in ampere-hours.	Efficiency.
10	10	100	95·3
9	10·8		92·8
8	11·8		90
	13·2	92·5	88
	14·7	88·5	84·3
	17	85	80·9
	20·4	81·5	77·6
	25·6	77	73·3

system has been further improved by the use of boosters [page 2247], which help in ensuring that although the demand is met, the battery is not excessively charged or discharged.

Continued

CHRISTIAN & BYZANTINE ART

Forms of Early Christian Buildings. The Basilica. The Byzantine Period. The Arts and Crafts of the Eighth Century. Saracenic Art.

By P. G. KONODY

EARLY Christian art is the connecting link between antique pagan and mediæval or Christian art proper. It fills the gap between the Classic and the Gothic period. It starts in the sheltering obscurity of the catacombs, whence it issues victoriously, spreading far and wide and annexing not only the material of the deserted pagan temples and halls of justice, but in many cases the very forms of construction and artistic expression. Thus in the West, in Rome, the Pantheon, a heathen temple, was adapted for the requirements of Christian service, whilst the form of the Roman basilica was, for a time, chosen as the definite form of early Christian church buildings. Columns and other remains of Roman buildings were freely used for these new edifices, cut down if too long, or added to if too short—put together as they happened to come to hand, without regard to the style of the capitals, shafts and bases.

The Basilica. The basilica lent itself most readily to religious service, owing to its division into the apse at the back, which was reserved for the bishop and the officiating priests, and the nave and aisles for the community. The altar was erected in front of the apse, under a canopy, or baldachino, supported by marble columns. A kind of triumphal arch separates it from the nave. The lofty nave is divided from the lower aisles by a colonnade on either side, which supports the clerestory wall, through the openings of which daylight floods into the interior. The entrance gates are opposite the apse, and access is gained through an open colonnaded court, or atrium. At times a transept was introduced which converted the plan into a Latin cross, of which the nave was the long arm. The niche-shaped apse, the walls of the triumphal arch, and sometimes the clerestory walls were richly decorated with figures of saints, either painted or in mosaic with plentiful use of gold. The most magnificent building of this type is the basilica church of St. Paul, Rome, which was destroyed by fire in 1825, but has since been rebuilt on the original plan [37].

Another form of early Christian building which was derived from Roman prototypes was the circular or polygonal baptistery, which up to about the sixth century was a separate building, and which was constructed on the plan of the Roman tombs, with the one difference that the columns which divided the interior, as it were, into a circular nave and surrounding aisle had to serve an architectural function as

37. INTERIOR OF THE BASILICA OF ST. PAUL, ROME

38. ST. MARK'S, VENICE *Brogi*

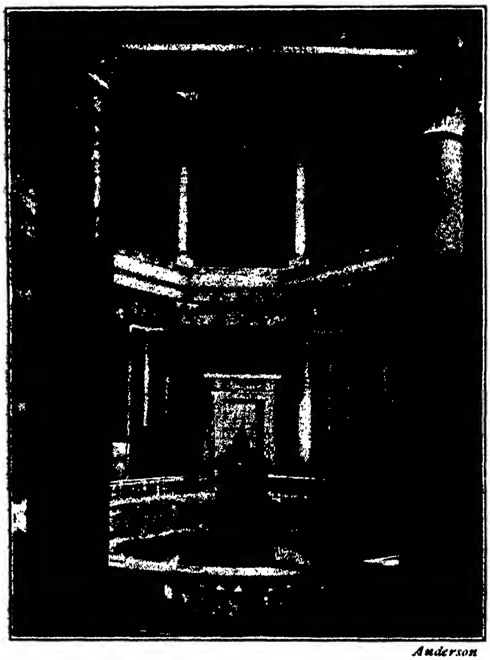
supports to the walls carrying the dome. Characteristic examples are the church of S. Stefano Rotondo, and the Baptistery of the Lateran, in Rome [39].

The Byzantine Period. With the decline of the Western Roman Empire, Byzantium, now known as Constantinople, became the centre of the civilised world. The churches erected in the time of Constantine and of his immediate successors still followed the basilica plan; but in the fifth century, under Justinian, the art, and more particularly the architecture, of the Eastern Empire received a definite stamp and fully developed the tendencies which constitute the Byzantine style. Byzantine life is reflected in the painting and sculpture of the period, which soon took settled, dogmatic forms incapable of further development. In architecture, however, the general use of the dome (which was taken from the East rather than from Roman examples), and all the changes it carried in its train, introduced new life and new possibilities into this art.

A lofty central dome is generally connected with quite a system of smaller cupolas and half cupolas, and necessitates a circular plan instead of the rectangular nave. In order to join the cupola to the square walls, the curved triangular pendentive or spandrel has to be introduced, resting on mighty shafts. Through these devices large wall spaces were gained, which gave special opportunities for sumptuous mosaic decoration. The kernel of the Byzantine churches consisted of bricks and mortar, cased on the outside with marble, and decorated in the interior with paintings and mosaics. In fact, whereas in Rome the dome was used in conjunction with the Greek trabeated system, and the effect depended on architectural articulation, in Byzantium the tendency was in the direction of flat surface decoration; and even the capitals, cornices, and friezes gradually lost their clearly marked classic play of light and shade.

Famous Examples of Byzantine Art. The church of St. Sophia, in Constantinople, now a Turkish mosque with all its former glittering splendour hidden under a coat of whitewash, is the most glorious example of the full flower of the Byzantine style [42]. The colossal building, the central dome of which has a diameter of 107 ft. and a height of 180 ft., was built by Justinian in five years (532-537), which constitutes probably a record in rapid building. Equally famous and characteristic is the church of St. Mark, in Venice [38], built about 1100 on the model of the church of the Holy Apostles in Constantinople.

From Byzantium the new style spread to Italy and the rest of Europe, taking root first in Ravenna, where the church of San Vitale combines many Byzantine elements, such as the gallery resting on the inner octagonal colonnade, with a plan based on that of a Roman temple. In Ravenna, too, we find for the first time an independent campanile, or bell tower, which is not joined structurally with the church, but rises from the ground in cylindrical shape, crowned by an almost flat roof. In Italy these independent campanili were generally adopted in Romanesque architecture, whilst in Northern Europe the bell tower formed an integral part of the church building. The ill-fated Campanile in the Square of St. Mark's, Venice, which collapsed a few years ago and is now being rebuilt, was the most famous erection of this kind. In England the Byzantine style of architecture has never taken root, but the late Mr. Bentley's new Cathedral



Anderson

39. BAPTISTERY OF THE LATERAN, ROME

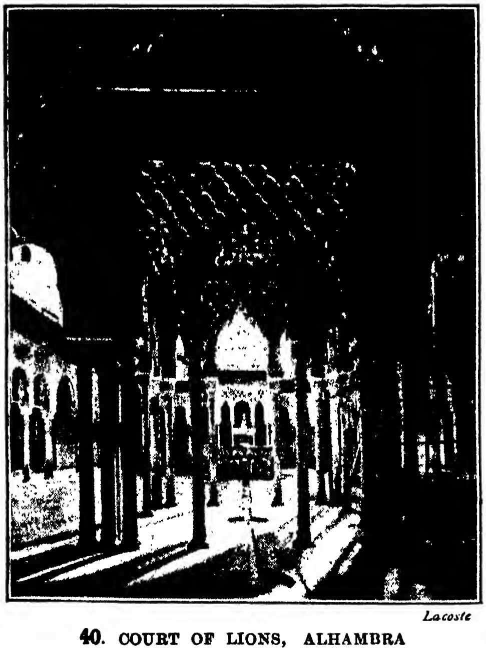
at Westminster presents a notable instance of a successful modern adaptation of Byzantine architecture.

Painting and Sculpture. In sculpture and painting, as in architecture, early Christian art in Rome was dependent on pagan prototypes. The subject was changed, but the manner remained the same, and the paintings in the catacombs bear a strong resemblance to the wall paintings of Pompeii. The fear of falling into the errors of pagan idolatry must have acted as a strong check to artistic activity, especially in sculpture, and, indeed, free-standing statues of the period are exceedingly scarce. In painting the danger was less obvious; it is less corporeal, and better suited to the expression of spirituality. Nevertheless, the earliest paintings show few traces of that spiritual ardour which later led Christian art to its most glorious achievements. The repugnance of the early Christians to representing divine ideas in human form led to the introduction of symbols, such as the fish, the alpha and omega, the cross, the palm branch, the vine, and the lamb. Amidst this new world of imagery are still found pagan ideas, such as Orpheus taming the beasts and personifications of day and night, rivers and mountains.

It is quite obvious that the original significance of such subjects had been entirely lost sight of, and that a new application had been given to mythological figures. In painting, as in the relief sculpture on sarcophagi, Roman art was thus perpetuated in a debased form. The artist no longer delighted in the beauty of the idealised human form, and gradually the sense of grace and pleasing proportions was lost, whilst a striving for the expression of spiritual grandeur took its place, until Byzantinism for a time veiled the offshoots of the Roman tradition, which, however, kept smouldering under the sumptuous formalism introduced from the Eastern Empire.

Alinari

41. MOSAIC FROM SAN VITALE, RAVENNA



Lacoste

40. COURT OF LIONS, ALHAMBRA

Gorgeous splendour was the keynote of the art that had developed in Byzantium, and found expression not only in the rich decoration of the churches, but in the very costumes, resplendent in gold and embroidery and precious stones, which had replaced the festive white garments of antiquity. A stiff, ceremonial formalism pervades everything—life as well as art. The striving for dignity, repose, and stateliness soon prescribed certain formulas for the representation of the human figure, and certain attitudes which reflect the strictly imposed ceremonial of the Byzantine Court. The figures are unduly elongated, the faces forced into a narrow oval, with large eyes, long, narrow nose, and small chin. The expression is as serious and dignified as the general attitude, and shows no trace of emotional life. Only the miniatures of the period retain faint echoes of the antique and show traces of individuality. The subjects are the same as in early Christian art: Christ in glory, surrounded by angels, the Virgin enthroned in solemn dignity, figures of saints conventionally robed in garments that never suggest the shapes hidden underneath them, and representations of the emperor or empress in state. The mosaics in the choir of San Vitale, in Ravenna [41], are the finest examples extant.

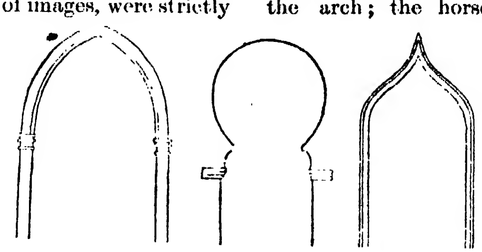
Arts and Crafts of the Eighth Century. In the eighth century the iconoclasts in blind fury destroyed most of the works of art of the Eastern Empire; and numerous painters, sculptors, ivory carvers, goldsmiths, and enamellers were driven from the country and took up their abode in Western and Central Europe. In miniature painting, for instance, Byzantine ideas soon ruled everywhere but in Ireland, where an independent ornamental style had taken root.

It is scarcely too much to say that from the eighth to the tenth century the crafts of Europe—

42. INTERIOR OF ST. SOPHIA, CONSTANTINOPLE Bonfils

always excepting the extreme north, where Celtic ornament had become an ineradicable artistic tradition—were entirely in the hands of Byzantine workers and their followers. Their skill in ivory carving, in metal work generally, and particularly in enamelling and filigree work, in weaving and embroidering, was inimitable.

Moorish Art. Byzantine influences, together with those of India, Egypt, and countries conquered by Mahomet helped to shape Moorish or Saracenic art. This art is entirely confined to architecture and ornament—which is generally applied to architecture—since painting and sculpture, or the creation of images, were strictly forbidden by the law of Mahomet. Even in architecture, the Mohammedans did not arrive at a settled style, and their buildings show a curious mingling of sober bareness on the exterior and exuberant ornamental fancy in the decoration of the interior. The mosques did not follow a fixed plan, prescribed by the use to which they were put, like the Christian churches, but are arranged in a haphazard fashion, the only common members being a spacious court with a fountain for ablutions, a hall for prayer, the "Holy of Holies" for the keeping of the Koran, and slender minarets for the muezzin's call to prayer. Columns and arches are abundantly used for the extensive halls and arcades, and the inner walls are covered with a wealth of arabesques and ornamental motifs in coloured tiles and carved stone.



43. POINTED, HORSESHOE, AND OGEE ARCHES

Extensive Use of Domes. Domes are extensively used, and the arch received a variety of new forms in the hands of the Arabs, who introduced the pointed arch, composed of two segments of a circle meeting in the centre of the arch; the horseshoe arch, formed of a segment of a circle which considerably overlaps the semicircle, and the ogee arch, which rises from each side like a semicircle and then turns upwards until the two lines meet in a point [43].

Examples of Saracenic art abound in Turkey, in India, in Western Asia and North Africa, and in Spain. The Alhambra, in Granada [40], and the Taj-Mehal, at Agra, are among the most famous buildings of this type.

Continued

Continued from page 3015

UNDERCLOTHING

The Outfit Necessary for Plain Needlework. Materials Required. Their Widths and Price. Woollen Materials. Trimmings

By AZÉLINE LEWIS

In the making of underwear a knowledge of the "art of sewing," or plain needlework, is the first requisite, for though the machine has superseded hand work of late years to a great extent, it cannot and will not do so on the finer and best kind of lingerie, in which hand work still reigns supreme.

Requisites. The requisites for plain needlework must first be considered.

Needles. A good supply of the best needles is essential; it is of no use to buy inferior makes, as these bend and are not to be depended on for good work. Various sizes are required, as stitches vary a good deal. Those known as "sharps" are most in use for plain sewing, Nos. 6, 7, and 8 being very useful sizes; but the finer ones will be needed for very fine work, with a supply of "betweens," which are shorter than sharps, and are required for fine whipping, insertions, etc.

As simple embroidery is also required in making good underwear, needles must be provided for this, and care should be taken that the eye will take the thread loosely, for unless this is relatively larger than the body of the needle the silk or thread will drag, and either pucker or tear the material and roughen the thread.

Machine needles are of a class by themselves, and each machine has its own special kind; but, of course, these must correspond with the work, and a coarse needle must not be employed for fine materials.

Scissors. Of these two pairs at least are required—one fairly large, for cutting out, and the other short, sharp, and not too finely pointed, for paring away edges of insertion, etc. If very sharply pointed they are liable to make holes or cut the lace which is being inserted, and cause almost irreparable damage. A medium pair for ordinary work may be well added to the list. A *stiletto* is also useful for making eyelet-holes and the first incision for a buttonhole, unless buttonhole scissors are added to the outfit.

Cottons. A fair supply of cottons of the unglazed variety will also be required. Here, again, a good make is absolutely necessary for good work, as the inferior makes twist and break, and the effect is spoiled. The numbers vary somewhat with the makers, but Nos. 40, 50, and 60 may be considered the most useful. For very fine work the higher numbers, 70, 80, 90, and 100 may be needed. For the machine, also, see that the make is good, and use a finer thread for the under than the upper one.

Harris's fine lace threads will also be found admirable for working insertions, etc. For the embroidery portions, Brooks's and the D.M.C. cottons may be recommended; but there are several other makes which are excellent for the purpose. Linen and flourishing threads will be found useful for linen and also in some cases for flannel work, whilst for marking purposes D.M.C. cotton should be employed, unless the woven letters or ink be preferred.

For flannel work a special make of silk is sold for embroidery, festooning, etc.

Thimble. A good, well-fitting thimble is also a necessity. If the indentations are at all rough they will catch and tear the thread or silk.

Emery Cushion. An emery cushion is also a very necessary part of the outfit for those whose hands are inclined to be warm, so that the needle may be passed through this and kept smooth.

Pins, Tapes, etc. Amongst the other requisites for plain needlework we must mention a bodkin for running in tapes and ribbons; some good mixed pins (very sharp-pointed ones); tape of various widths, the smooth India or China make sold wound in oblong forms being the best; linen and pearl buttons of assorted sizes, the former should be all linen, not with holes, as these, when washed, are apt to discolour the material; fine piping cord; a lead pencil to define width of tucks and hems; a small, sharp penknife for unpicking, though this should not be used unless absolutely necessary; a little wax for strengthening cotton if required in gathers, etc., and for the machine if the material contains much dressing; and a good yard measure.

Materials Employed. The materials generally employed in the making of underwear are given below, with their respective widths, as they vary a good deal, and thus considerably affect the quantities required for the different garments.

Longcloth and Calico. These are employed for ordinary underwear, either plain or twilled. They are usually a yard wide, although the better qualities run to 41 in. and 45 in. in width.

Madapolam. This is a very fine, soft make of longcloth, which is generally employed for fine underwear, as it is almost entirely free from dress. It is about 42 in. wide, and may be had in a good quality from 10¾d. per yard.

Unbleached Calico. Unbleached calico is much used by the working and poorer classes on account of its cheapness, as it can be bought from 2d. per yard. If properly washed it soon loses its yellowish tint, and is excellent for charity purposes.

English Nainsook and Cambric. These are fine and thin in texture, and are used for fine underwear—chemises, camisoles, frills for ornamental purposes, etc., and vary from 30 in. to

45 in. in width, the prices being about the same as longcloth and madapolam.

French Nainsook. Somewhat finer in texture than the English make, and is about 42 in. wide.

French Cambric varies from 26 in. to 34 in. in width.

Irish Cambric. 26 in. wide.

French Mull. This is also employed in the best underwear, and is 47 in. wide.

Linen. Though not so much used in these days, linen is still extensively employed in the finest makes for the highest class underwear.

Irish Linen. About 36 in. wide.

French Linen. 32 in. wide.

French Linen Lawn. This is a particularly fine and beautiful make of linen, varying from 36 in. to 40 in. in width, but is somewhat expensive, the best being about 4s. 6d. per yard.

Irish Linen Lawn. Runs about 36 in. in width, and, like the last eight makes, is only suited to those who need not consider the price.

Washing Silk. In addition to the above-named materials, silk is now largely employed for fine underwear. It should be of a good quality, the twill make being the best.

Coloured Underwear. White materials are generally preferred for underclothing, but fashion at times takes a fancy for colours, and cambric and silk in pale blue, pink, and heliotrope, and even black, are seen in our fashionable "lingerie" shops, and worn by those with a taste for the fanciful.

Since woollen underwear is now so much worn, a list of the materials employed must of necessity be included.

Flannel. For the best woollen undergarments fine twill or Ceylon flannel are the usual materials, together with Viyella and some of the finer Welsh makes, with the gauze flannel for summer and tropical wear. These vary from 27 in. to 36 in. in width. It is, however, not advisable to purchase a too fine or close make of flannel, as it washes hard and thick.

Bath Coating. This is a kind of flannel very suitable for petticoats, being somewhat stronger and thicker than the usual make. It varies from 45 in. to 54 in. in width.

Nuns' Veiling. Those who want something warmer than longcloth and yet not quite so heavy in texture as flannel often select nuns' veiling, which makes up and washes admirably. It should, however, be of a good quality, and is about 44 in. wide.

Scotch Wincey. This, a mixture of cotton and wool, is not a new material by any means, but of late years it has come much to the fore for making underclothing, forming the link between calico and flannel. It is smooth in texture and both wears and washes beautifully, as it has not the tendency to shrink which is one of the disadvantages of the latter, and is in many ways preferable to the flannelette which it may be said to replace. The finer makes can almost be drawn through the proverbial ring, but the material can at present only be obtained in Scotland.

Flannelette. This has of late years taken a very favourable place in public estimation on account of its cheapness and its comfort for all kinds of underwear. Its inflammability is, however, its disadvantage, and many deaths have taken place through this dangerous quality, particularly among children. There is, however, a "non-flam" variety obtainable, in which the dangerous element has been eliminated, and which we have tried with perfect success. It can be had, like the other makes, in all colours and qualities, and its non-inflammable quality is not impaired by washing.

Cosy Cotton Flannel. Similar to flannelette, being soft and warm, and, like the above material, is, in spite of its woolly texture, made of cotton.

Trimmings. With respect to trimmings, Swiss and Madeira embroideries are generally employed, with muslin and jaconet embroideries for finer wear. Coventry frillings are also largely used, and these are manufactured in a great variety of widths and edgings, and only require drawing up by the thread woven in the upper edge before sewing on. They wear admirably.

Lace is also much used for fine and ornamental underwear, Torchon and Valenciennes being the two kinds adapted for the purpose, in the real and imitation varieties. Real Valenciennes is rather expensive, whilst real Torchon is somewhat cheaper, but excellent and good imitations of both can now be obtained which wear and wash well. The round ground Valenciennes is better adapted to underwear than that with a diamond groundwork, being somewhat stronger and better able to resist the onslaughts of the average laundress.

For flannel underwear, flannel embroideries and insertions are employed, as well as Torchon lace, whilst hem-stitched silk frilling adds very much to the daintiness of a flannel nightdress.

Hairpin and crochet work in silk make a charming trimming for flannel wear, for which the worker will find directions in various books on fancy work, as well as the crochet and knitted laces which are much liked by many for the adornment of their undergarments.

Machine-made braids with various kinds of fancy stitching can be bought ready made, and are used in the less expensive kinds of underwear; but in the best class of lingerie, as before said, handwork alone is required. Much practice, however, is needed before this kind of underwear can be attempted; the fine tuckings, insertions, and embroidery on the finest of materials make some of the garments quite works of art.

Ribbon insertions are required for the edges of camisoles, chemises, etc., or any portion requiring a ribbon run through in the more ornamental lingerie. They may be of lace, muslin, jaconet, or longcloth, according to the edging employed in trimming, and vary from three-eighths of an inch to one inch in width.

Veining, or beading, is a very narrow open-work insertion used to unite seams for ornamental purposes in the best underwear.

Continued

PLATING & BOILER-MAKING

Plating Materials. Riveting and Caulking. Angle-iron Smiths' Work. Boiler-making. Types and Details of Boilers. Furnaces, Flues, and Tubes

WORKSHOP PRACTICE
continued from page 2992

By JOSEPH G. HORNER

THE plating department has much in common with the smithy on the one hand, and the boiler shop on the other. The materials used are similar, and to a certain extent they occur in the same forms—that is, bars and rods are used in all three departments. But the smith does not work with rolled plates, nor with rolled sections, such as angles, channels, and beams of H and other forms, each of which is used to a much greater extent by the plater and boiler-maker than are bars and rods. This fact adds to the methods of the smith working on bars and rods, a large number of other details peculiar to the working of plates and rolled sections. And these involve the use of many machines and many appliances which are employed only in these departments.

Treatment of Plates. So far as the working of bars and rods is concerned, the boiler-maker and plater adopt the methods of the smith, described in last article. This involves work done at the forge and anvil, such as drawing down, upsetting, bending, welding, and punching, and the tools used are similar. But there is little scope for die forging, the exceptions being the small fittings for boilers, tie-rod eyes, etc. The use of plates and rolled sections, however, involves the cutting up of these to dimensions, shearing, and sawing, planing, punching, drilling, riveting, caulking, and a good deal of awkward welding also—awkward because the rolled sections do not lend themselves to the simple forms of scarf and butt joints as bars and rods do. These trades, therefore, stand apart from that of the smith, and are actually subdivided, much as moulders' work is, between half a dozen groups of craftsmen.

Iron and Steel. Plates—whence the trade receives its name—are rolled in thicknesses ranging from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. Most of the work of the shop is done with those ranging from $\frac{1}{4}$ in. to 1 in. They are received from the steelworks with the edges roughly shorn. These edges in all good work are planed in the shop in a special side-planer before being worked up into place. Also, they are seldom level, and if wanted so, they have to be levelled with hammers, or, in the good shops, in flattening rolls. If they have to be curved, they are treated in bending rolls.

Rivet Holes. As plates and sections have to be united with rivets, the rivet holes are either punched or drilled. Punching is done on cold plates, and thus differs from the punching done by the smith on heated bars. It is not done by hammering, but by simple pressure, the punch A [**209**] being actuated by a cam, or eccentric, or hydraulically. In this illustration, B is the plate punched, the thickness of which must not exceed the diameter of the punch and should be less; C is the *burr*, or punching, falling out. This is always thinner than the plate. D is the *bolster*, steel-bushed; E is the *stripper* to prevent the plate from rising on the withdrawal of the punch. In bridge and girder work it is usual to punch a number of holes at a time in multiple punching machines, but the common punching machine produces only one hole at a time, so that the plate has to be shifted and reset for each hole.

Disadvantages of Punching. The result of punching is severe stressing of the plate in the immediate vicinity of the hole, due to the violence of the detrusive action, and though the evil is not generally apparent at the time, the after results are frequently fractures, due to the extension of the very minute cracks produced immediately around the hole. But if the punched hole be enlarged by a reamer, cutting away from $\frac{1}{32}$ to $\frac{1}{16}$ in., the incipient cracks are then removed and no subsequent risk is run. But this reamering occupies time, and so the practice of punching has been largely displaced by drilling rivet holes. For many years punched holes were permitted in boiler practice if they were subsequently reamered, but now it is not allowed in any high-class work. Although it is still retained in much bridge and girder work, even in this the tendency is towards the substitution of drilling for punching.

But another evil nearly inseparable from punching is the overlapping of the holes when plates are punched separately. Thus, **210** shows fair holes when reamered or drilled; but **211** shows holes overlapping slightly. Often in ship and girder work the overlap is much worse than that indicated, amounting to a quarter, a third, or even half the diameter, and then *drifting* is practised, unless inspection is keen. In drifting, a tapered mandrel, or round rod, is inserted and hammered into the holes, pulling and straining the plates, or *drifting* them sufficiently to permit of the insertion of the rivet.

Riveting. This is the operation of closing and uniting the plates to each other, and to the rolled sections. All this work was formerly performed by hand hammers; but unless in exceptionally awkward positions, where machines cannot be brought into play, little hand work is done now in modern shops. An immense number of machines, fixed and portable, are employed for closing rivets by power agencies, as water, compressed air, and steam. Not only is the cost lessened by comparison with hand riveting, but the work is more reliable.

When rivets are closed by hand the tails are beaten over with hand hammers, and neatly finished with a *snap* [212], which is struck with a sledge hammer. In machine work the ram slides out and squeezes the tail into shape at once, or beats it down in a few blows.

Caulking. The joints of the plate faces are rendered water and steam tight by caulking. That is, the edges are burred up with *caulking tools*, a group of which is shown in **213**. The differences in these are: A is the *broad caulking* or fullering tool, sometimes used alone, but more often following the narrower tool B. The objection to the latter is the risk of its bending the plate, and opening instead of closing it, as at side A in **211**, where the nick made by the caulking tool is also indicated. In **213**, C is a tool used round rivet heads in conical tubes, D is a heavy tool which is struck by the sledge. Caulking is now largely done by pneumatic hammers, which operate much more rapidly than the handworker.

Rolled Sections. The rolled sections which fill so large a place in the plating shop and to a less extent in the boiler shop include angles, channels, joists, and tees [**214**, black sections], the functions of which are primarily as a means of union for plates, or as bracings. But they are also used largely as elements from which beams, stanchions, and columns are built up cheaply. The number of combinations thus available, and the range of their dimensions run into many hundreds; in fact, to illustrate and describe them and their functions would occupy a goodly volume. Of the sections themselves shown in black [**214**] (against bending blocks, to be noted presently), the most common is the *angle* A. The flanges are equal as shown, or unequal in width. They are *square throated* or *round backed*, and *bulbed*, *right* angles [A] or *acute* or *obtuse* [B], and all in a wide range of thickness and width of flange. The *channel* C is made in a similar range of sizes, and with different proportions of flanges and web. The *joist*, *beam*, *girder*, or *H-section*, D, is of extensive utility, and is often in itself a cheap substitute for beams built up of plates and angles, or of plates, angles, and bracings. The *tee* section, E, is equally useful. A variation on it is the *bulb tee*, used much in shipbuilding. The *rail* section, F, is used to a considerable extent in some classes of plating for civil engineers, especially in the form of old rails.

Angle-iron Smiths' Work. The operations by which these rolled sections are prepared for the plater are largely done by men distinct from the platers, the *angle-iron smiths*, whose work lies wholly at the forge. They bend and weld where welding is done, and flange plates, if this be done at the forge, though most of it is now appropriated by flanging machines. The equipment required for this work includes a large variety of heavy cast blocks, besides the usual appliances of the forge, which are nearly common with those employed in the ordinary smithy. Sections are generally now cut off to lengths with a circular saw (*cold saw*). The welds are made almost invariably of the *glut* form, and work is done in detail at successive heats, since it is impossible to weld simultaneously round two webs of, say, an angle.

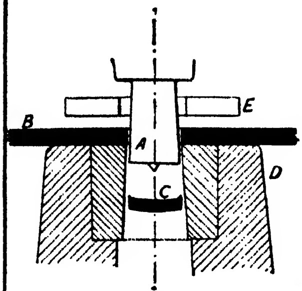
The blocks shown in hatched section in **214** are examples of bending blocks, each suitable for the rolled section shown lying against it. The shapes imparted in plan view may be anything, being made to suit the curve or bend required, such as circular or angular, or embodying combinations of curves and straight portions. The holes seen in the blocks are for bolting or cottaring them down to the *block* [**215**], on which the operations of bending are commonly done, the case of special blocks excepted. The large number of holes cast in this block permits of bolting anything down upon it for secure fixing. Frequently two or three such blocks, but without holes, are bolted together edgewise to form one large block to be used for levelling plates upon, a subject to be noted presently.

The Glut Weld. This form of weld was illustrated in the article beginning on page 2983. If a glut weld has to be made in an angle section, each side of the angle is done separately at successive heats. It is necessary first to scarf the ends, which is done by cutting them while hot with a hot sett. The ends are then brought into opposition and retained with clamps, and the joint portion put into the fire and brought to a welding heat.

The glut is also heated in the same fire, or in one adjacent. Both are taken out at the same instant to the anvil, and a few blows with a hand hammer effect the weld. If the joint be for an angle, a second heat has to be taken for the other web. Only after the welds are made is there any attempt to impart a neat finish to the surfaces, for which another heat may or may not be required. It is not judicious to do much hammering on iron or steel after the metal has lost its redness. The results are more serious in the case of steel than of iron, consisting of a marked reduction in ductility.

If a long glut weld has to be made, it may often have to be done in more than one heat—say in lengths of 5 in. or 6 in. at a time. A separate length of glut is used at each section. Gluts are used not of the length of the weld to be made, but 3 ft. or 4 ft. longer, to afford a length to be held in the hand (a *porter bar*). The supplementary portion is cut off after the weld is made.

Welds of Corners. In plated work a good deal of welding of corners is rendered necessary because rolled sections cannot be bent at right or acute angles on account of the crumpling, or extension of the web that lies flatwise in the plane of bending. This subject of crumpling and extension on opposite sides of the neutral axis was explained in last chapter. It is necessary, before welds can be made in any of the sections shown in **214**, to cut away in some cases, or to insert gluts in others. Thus, in **216**, if an angle bent inwards has the web on the inside, then a portion must be cut out as at A, and the ends overlapped, B, C, and welded. The bending of an uncut web would produce much crumpling



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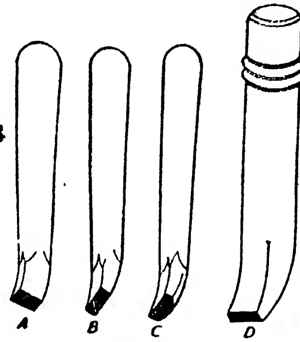

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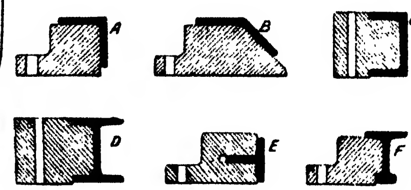

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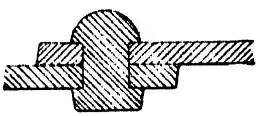

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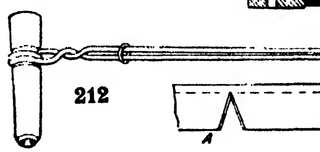

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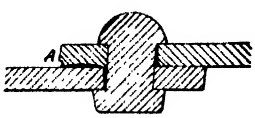

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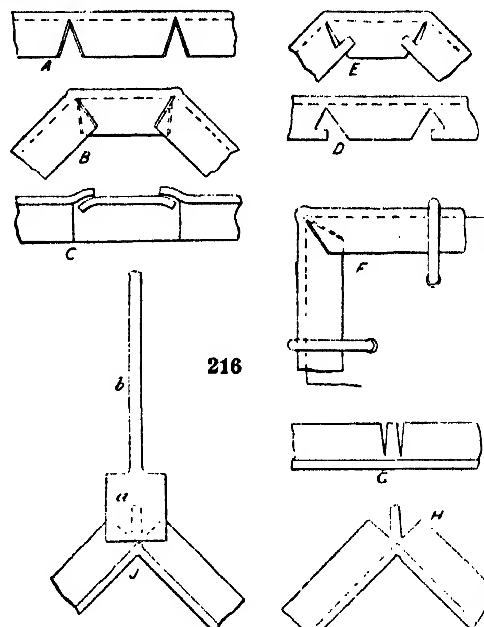

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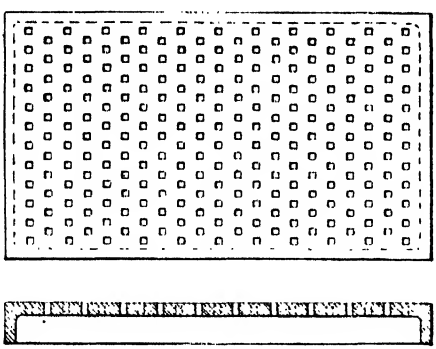

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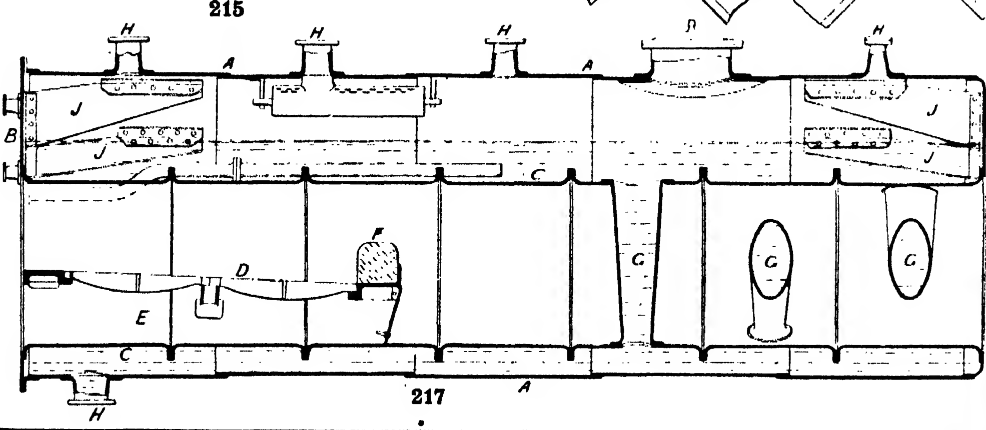


217

OPERATIONS IN PLATING AND BOILER-MAKING

209. Punching **210** and **211.** Riveting **212.** Snap **213.** Caulking tools **214.** Rolled sections and bending blocks **215.** Bending block **216.** Welding angles **217.** Cornish boiler

up of the metal. An alternative device to that at A is shown in D, where a notch is cut, with a projecting lip, and when the angle is bent the lip overlaps and is welded. An open space is left which is filled by welding a punched burr there. F shows one method of securing an angle on a block during the act of welding it. If an angle, when bent, has its web on the outside, then a portion must also be cut away, and a filling-in piece inserted. The reason is that the bending of an uncut web would produce either extreme attenuation of the metal or its actual rupture. The latter would occur when the tensile stress exceeded the tensile strength of the material. And what would occur in angles also applies to tees, channels, and other rolled sections. G shows the notching of such an angle, H its appearance when bent, and J the same ready for welding. A flat piece, *a*, is laid on to cover the joint, being attached to a porter bar *b*, which is cut off after the welding is completed.

Boiler-making. This is a trade which has more in common with the work of the plater than of the engine smith. It involves plating, and the work of the angle-iron smith, as well as some of the elementary processes carried out by the engine smith. The materials for boilers occur chiefly in the shape of rolled plates, angle sections, rivets, and stays, which require different treatment from bars and rods forged at the anvil. The range of operations involved includes those of the smithy, but extends much beyond them. Besides this, the types of boilers vary so widely that each great group involves the employment of machinery more or less specialised and requires the services of men who are specialists.

The boiler-maker employs steel plates, which have to be levelled, and bent, drilled, and riveted. He does not use so many rolled sections as the plater, his requirements being limited to angles and tees chiefly. Machine riveting has displaced hand riveting with him as it has in the plater's work. As these trades occupy so much common ground we shall not repeat statements that have been already made, but give attention to a few matters that relate to boiler work only.

Difference Between Boiler Work and Plating. Put in a nutshell, boiler work differs mainly from plater's work—*i.e.*, bridge and girder and cognate structures—in the fact of its having to withstand the effects of high temperatures and high pressures. These are the two conditions that render boiler-making a trade apart from plating, notwithstanding that it is so closely allied to that and smiths' work.

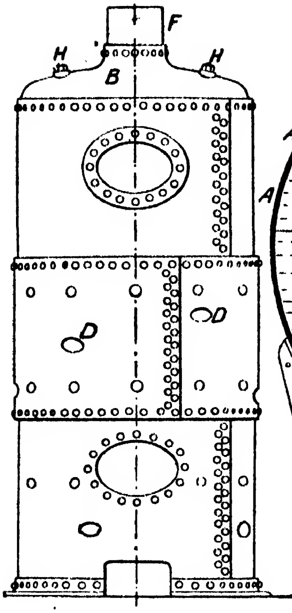
Dock gates, penstocks, the walls of tanks, and hydraulic fittings have to withstand severe pressures which are often as great as those in steam boilers. But the conditions are not identical between the steady, solid pressure of water and the pressure of elastic gaseous steam. Rupture in the first simply means leakage, nothing more; in the second it involves terrible destruction, so that in boilers the materials must generally be of better quality than those used for plating. Shearing and punching as finishing operations have long since been abandoned, and very careful caulking is essential to make steam-tight joints without injuring the plates. Besides this, there is the vast amount of practical detail involved in furnace construction and in the precautions taken to avoid as far as possible the effects of expansion and contraction of boiler parts due to heat, which have destructive results on joints, seams, flanges, and plates. Connected with this is the subject of *staying*, or affording just the right amount of support to plates much too weak in themselves to resist high pressures.

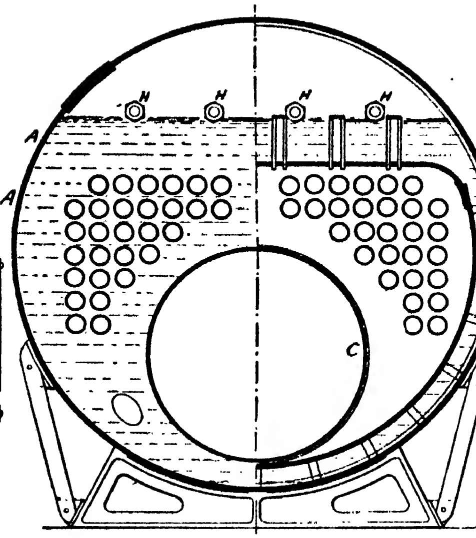
Details of Boilers. The principal elements in boiler construction are the following: the shell, the furnace, or fire-box, the tubes, the combustion chamber, the smoke-box, and the fittings. With work outside the boiler, such as its seatings, brickwork flues, chimney, mountings, including the furnace doors, mechanical stokers, and economisers, when such are used, the boiler-maker is not concerned. His work ends when the actual boiler is ready to be put into its place. As we cannot describe in the space available the construction of the different kinds of boilers, the remarks to follow will be generally applicable to any boilers in which the elements named occur. Three boilers are illustrated as examples on which to hang the remarks to follow—namely, the *Cornish* [217], the *vertical* [218 and 219], and a *return-tube marine* (*Scotch*) *boiler*, with a single furnace [220 and 221].

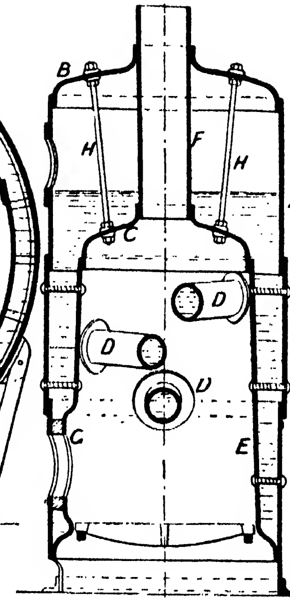
The Shell. This signifies the outer portion of the boiler [A in 217–221], in which the water and steam are confined, and which is subject to pressures tending to burst it. It is termed the *shell* in all boilers except the locomotive, in which it is the *barrel*. In horizontal boilers [217, 220 and 221] the longitudinal axis of the shell lies horizontally. In vertical ones [218 and 219], the axis lies vertically.

The Shell Plates. Only in a vertical boiler of small dimensions is the cylindrical portion of the shell rolled in a single plate. In the larger verticals, and in Lancashire, Cornish, marine, and locomotive types there are two, three, four, or five rings of plates required to make up the length. But except in the large marine boilers, a single plate is now generally used to bend each ring from, instead of three plates as was formerly the practice. This change is due to the fact that plates can be manufactured in larger sizes in steel than in iron. From this results the important advantage that the longitudinal seams of shells are reduced from two or three to one, and a troublesome source of grooving thereby removed. Not only can seams be kept away from the bottom of the boiler where deposit is liable to occur, but having one seam only, made with double butt straps, the circular shape of the shell is retained, which was not the case when longitudinal lap seams were common.

The edges of shell plates are planed in a plate-edge planing machine, and rolled to the circle







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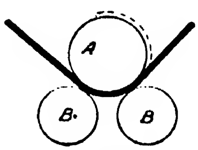

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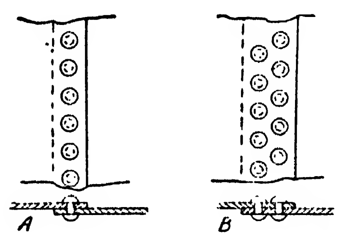

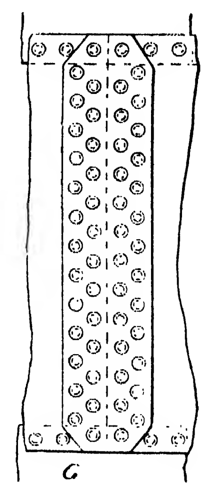

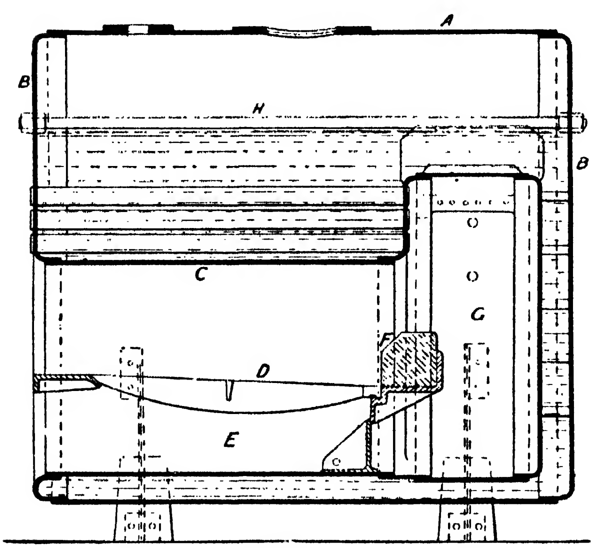

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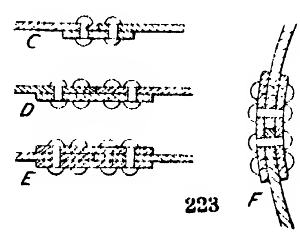


223

DETAILS OF BOILERS

218 and 219. Vertical boiler **220 and 221.** Return-tube marine boiler **222.** Action of bending rolls
223. Various riveted joints

in bending rolls, having one housing removable to permit of sliding the complete cylinder off endwise. The essential action of the rolls is seen in **222**. By the adjustment of the upper roll, A, relatively to the lower ones, B, curves of varying radius can be produced.

The Riveted Seams. There are two kinds of seams: the *longitudinal*, or those which run lengthwise of the boiler, and form the joints of the rolled rings, and those which run circularly round the boiler—the *transverse* seams—and unite the rings to each other. As calculations show that the latter need have only half the strength of the former, single riveted [**223**, A], or double riveted lap seams [**223**, B] are used for the circular joints. But the longitudinal seams are seldom lapped, and then only in boilers for low pressures, because a lap, in a shell required to be truly circular, breaks the continuity of the circle. All such seams therefore should be made with *butt straps*—that is, narrow strips riveted against the face or faces of the shell. These are *single*, *double*, or *treble riveted*, the rows of rivets being doubled or trebled for the higher pressures. C is a single-riveted single butt strap joint, D is a double-riveted single butt strap, and E a double-riveted double butt strap, which is generally employed when pressures exceed about 100 lb. to the square inch. F shows double butt straps on a circular shell, and G is a plan view of one strap shown in connection with two circular seams, single riveted; **224** shows a longitudinal lap seam, double riveted, and a circular lap seam single riveted, together with the thinning and spreading of the corner, adopted when three plates have to cross or overlap.

The butt straps must have both edges planed ready for subsequent *caulking*. Caulking on roughly-shorn edges is now never permitted in boiler work. The rivet holes are now generally drilled with all the parts in place. Formerly they were drilled (or punched and reamered) before the plates were bent. But there are a number of special drilling machines now designed for boiler-shop use, in which the rings and butt straps, being held temporarily with tack bolts, drill the holes in place, and remove the *arrises*, or sharp wire edges, from the holes. The shells are then riveted up by machines which close the rivet tails by hydraulic or pneumatic pressure, the boilers being slung up in a crane during this operation.

The Boiler Ends. A shell is not complete without its ends [B in **217** and **221**]. These ends have holes either for furnaces or fire tubes. They are prepared and riveted to the shell and to the furnace ends in the case of Cornish and Lancashire and marine boilers. These ends must be perfectly flat. The methods of flattening them are precisely those adopted in levelling all plates used in the plating and boiler shops. Mention has been made of this as the fact whence the levelling block [**215**] derives its name, and this is the place to offer some observations on the very important operation of flattening plates.

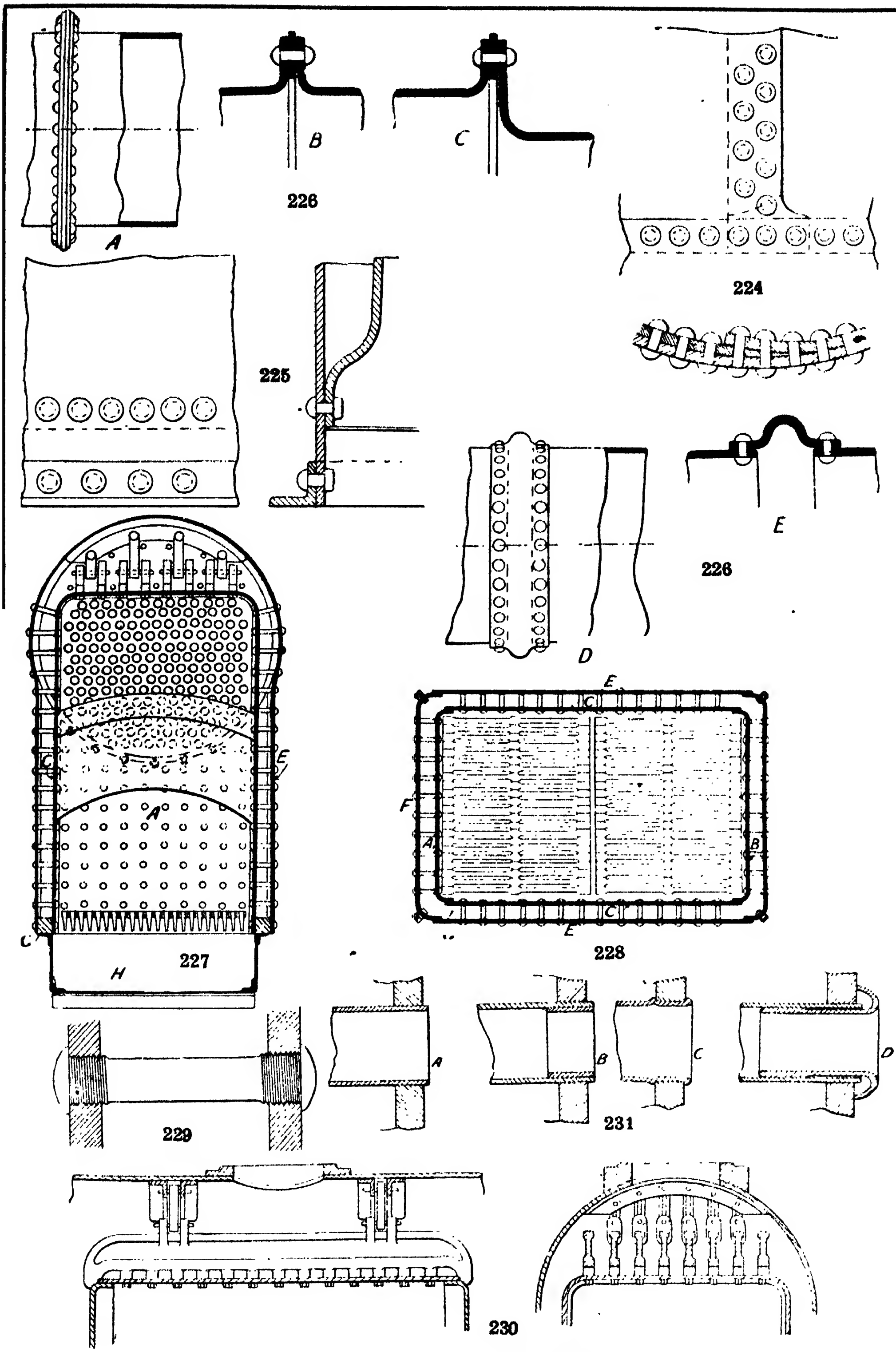
When plates come from the rolling mills they are not flat (unless ordered so), and part of the work of the boiler-maker or plater lies in levelling them.

Levelling Plates. This is done either on the block, like **215**, but plain, with hammer blows, or between rolls—*flattening rolls*, often termed the *mangle* in the shops. The first is not so good a method as the second, and it is much more tedious, but it is an operation requiring much skill and experience. In hammer flattening the blows are never delivered on the area that is actually bent or buckled, but on those adjacent. The reason is that buckle is due to an extension of the fibres, and hammering there would extend them still more. But hammering on the encircling metal extends that, leaving the buckle free to straighten itself therein. Though plates can be made perfectly level in this way, yet much time is occupied. The operation is noisy, and excessive hammering tends to induce a brittle state in the metal. When plates are flattened in the rolls, these differ from the bending rolls only in the number of rollers used. There are three in the first, usually seven in the second—four below and three above—or vice versâ. But it is clear that by the passage of a plate between top and bottom rolls arranged with the centres of each alternating—that is, the centre of every roll falling plumb between a pair above or below—the effect is to squeeze and level all inequalities. Two passes, or three at the most, suffice to straighten the most crooked plates within five minutes, against, perhaps, an hour occupied in hammer levelling.

Flanging Plates. Formerly the boiler ends were united with internal rings of angle iron to the shell. Now the practice is to flange the back plate, turning the flange within the shell, and to unite the front plate with a ring of external angle iron [**217**], or by flanging. Marine (Scotch) boilers have both front and back plates flanged inwardly [**221**] and sometimes outwardly. Vertical boilers [**218** and **219**] have their *crown plates*, B, flanged inwardly, and occasionally outwardly. The *furnace crown*, C, is also flanged. The bottom end of a vertical boiler is formed by the *foundation ring*, by which the fire-box is united to the shell, or the fire-box is flanged outwardly [**219** and **225**].

Reasons for Flanging. Flanging has displaced angle-iron joints—first, because the latter were a frequent cause of grooving; secondly, because steel is more readily flanged than iron was; thirdly, because machines have nearly displaced hand flanging. The boiler-maker often has to do hand flanging in the smaller shops which are destitute of machines, though these usually now send their flanging to be done in the big works. When effected by hand, the operation is rather tedious, so that flanging a plate might occupy two or three men a day, against, say, four men half an hour with a press, in which the actual turning over of the flange does not occupy more than a minute. One of these presses with a plate *in situ*, as just flanged, was illustrated in the course on Applied Mechanics, page 1221, **154**.

Press flanging is also better from the point of view of homogeneity of the plate. When done by hand work, short heats of 10 in. to 12 in. have



DETAILS OF BOILER CONSTRUCTION

224. Thinning corners 225. Flanged fire-box 226. Adamson and Bowling furnace seams 227 and 228. Fire-box of locomotive boiler 229. Screwed stay 230. Girder stays 231. Tube ends

to be taken in succession, and that length of flange is hammered over a block at a single heat; so that the work has to be moving between the fire and the bending block several times before the circle is completed. In a press the whole of the flanging is done at one heat, marine boiler fronts excepted, and the danger of working at the blue-black heat incidental to hand flanging is avoided, because the flange is still at a good red when finished. Consequently, when ends are flanged by hand they must be *annealed*, an operation which is not necessary with press work. The radius of the flange is important. A large radius gives more elasticity to the end than a small one does, with less liability of grooving.

The Furnace. The furnace, as distinct from the fire-box—the functions of both, however, are alike—denotes the tubular form (*furnace flue*) used in internally fired boilers. These include the Cornish [**217**, C] and Lancashire, the marine [**221**], and allied forms having one, two, three, or four furnaces arranged side by side longitudinally. The furnace of the vertical type [**219**, E] is a *fire-box* and that of a locomotive is similarly named. The furnaces in **217** and **221** are riveted to the front and back plates. The *fire-grate*, D, *ash-pit*, E, and *bridge*, F, occupy the four to five feet of length next the fire door, and the space beyond forms a *combustion chamber* in which the gases are burnt.

The furnace is subject to pressure from without, and is thus in a far less favourable condition than the shell. It is also liable to suffer by the accumulation of calcareous and other hard deposits which come from the water over the fire, and lessen the transmission of heat from the fire to the water, and which also, by causing overheating, increase the natural weakness of the furnace to resist collapse.

Furnace Design. There is a large amount of interesting history in connection with the development of boiler furnaces, ranging from the plain or hooped furnaces, which were the causes of numerous accidents, down to the present forms, with the *Adamson seam* [**217** and **226** A, B, C], the *Bowling hoop* [**226**, D, E], and other allied designs, and the *corrugated* types. The net result may be summed up thus. Instead of a long weak tube having no adequate support away from the immediate vicinity of the ends, the length is divided into several short, practically independent sections, the lengths of which are determined by the positions of the flanges, or hoops.

In **226**, A shows a portion of a furnace flue, partly in external view, partly in section; B shows the Adamson flanged joint, or seam, enlarged in section; C is a later alternative in which the flue sections are of different diameters, with the object of improving the efficiency of combustion of the gases, and giving greater longitudinal elasticity; D shows a Bowling hoop, partly in external, partly in sectional views, and E is an enlarged section through the joint.

Making the Flues. Furnace flues formerly were made with the longitudinal seams riveted, which proved a source of danger. They are now invariably welded. Flanging of the ends [**217**] is also substituted for rings of angle iron, unless, as in some marine boilers [**221**], the end plate is flanged inwards to meet the flue. The flanging of furnace flues is done in a special machine, which rolls over a flange in about a minute. If Bowling hoops are used, these are rolled also. The drilling and riveting are done in machines designed specially for this work. In some the flues are held in a vertical position, in others in a horizontal. There is really no hand work in the manufacture of furnace flues in up-to-date boiler shops. The exception sometimes is the welding up of the longitudinal seams. But generally that is done under a power hammer, the tube being moved under it along a mandrel. Lap or glut welds are both used in these.

Galloway Tubes. Furnaces have *Galloway*, or *cross-tubes*, C **217** being the first-named, and D **219** the second. These are made and inserted before the furnace lengths are riveted at the circular joints. The tubes are prepared by welding and flanging, by methods similar to those employed in making the flue lengths. The longitudinal joint is either glut or lap welded. The flanges are still often turned by hand, by hammering them in short sections, followed by annealing. They are also turned in special machines. They are generally riveted into the furnace flues by the flanges. But sometimes welding is adopted, although less frequently than formerly. Then there is no flanging done, but only an upsetting of the ends sufficient for welding. The general objection to welding is the difficulty of removing a tube for the purpose of renewal or repair. When a tube is flanged, the rivets as well as the flanges are usually caulked with the tool C in **213**.

Union of Furnace to Shell. When the furnace has been riveted up, it is inserted into the shell. Generally it is riveted to the back end plate first, and then the front end plate is brought up to it and riveted, and the diagonal stays are riveted at the same time. Here the work of the boiler-maker ends on the furnace flue. The furnace-doors, fire-bars, and bearers are inserted by another set of men after the boiler proper is completed. In the marine or Scotch boiler the furnaces are generally strengthened by corrugations, and divided by Adamson seams. They are riveted at the front end to the flat plate there, and at the back to the tube plate of the combustion chamber.

The Fire-box. This is the term given to the furnace used in a locomotive type of boiler, and in verticals [**219**, E], although the two forms differ. In the locomotive [**227** and **228**] it is a nearly rectangular box; in the vertical type, [**219**, E] it is a frustum of a cone. In both, the fire is at the bottom of the box on the grate-bars, and the flame occupies the remainder. In the locomotive the hot gases pass through the horizontal fire-tubes to the smoke-box; in the verticals they pass up through the uptake, F, directly to the chimney (not shown), placed above the uptake.

Flanging is the only means of union adopted in locomotive fire-boxes, having long ago displaced angle-iron joints, found in other kinds of boilers. Hand flanging has also been superseded by that of the press, fitted with massive dies of cast iron. A press turns the flanges at one heat in about a minute.

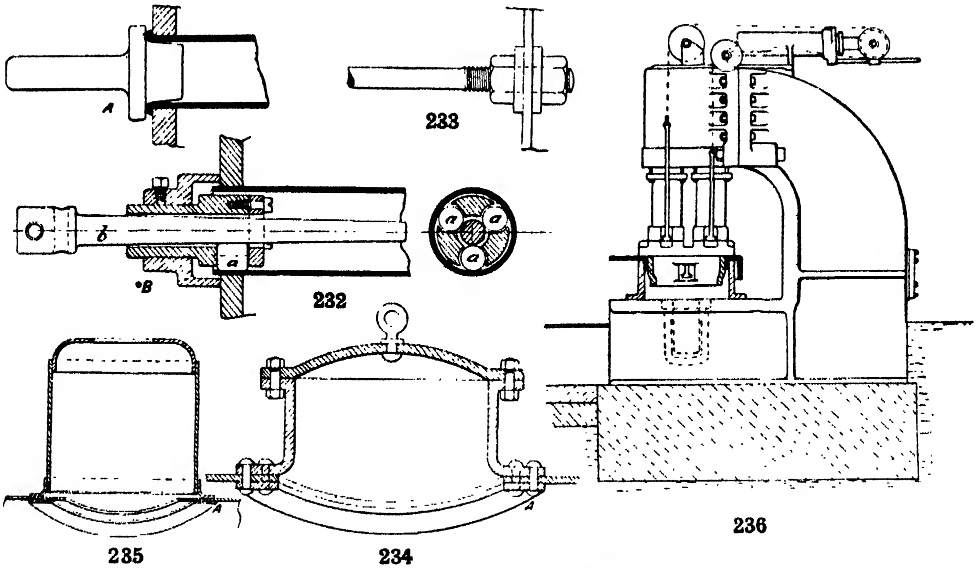
Locomotive Fire-box. The fire-box [**227** and **228**] comprises the *tube-plate*, A, and *back plate*, B, both flanged inwards towards the fire-box space, and united by the covering or *wrapper plate*, C, bent round in one sheet to form the top and flanks of the fire-box. This is the fire-box or actual furnace. But it has to be united to the boiler shell, or barrel, and this is done by an extension of the latter termed the *outer fire-box*, though it is a part of the water and steam space. At the front (viewed from the footplate) the back plate D, in which the fire-hole is cut, is flanged inwards and connected to the barrel first by a wrapper plate, E, riveted to the flange of the back plate at one end, and to the barrel, and throat plate, F, at the other. The throat plate is double flanged: forward to meet the outer fire-box plate, and backward to embrace the lower part of the barrel. Between the back plate, the throat plate, and outer covering plate, the fire-box, already riveted up and caulked, is inserted, and united to all three plates at the bottom by a *foundation ring*, G, of rectangular outline in plan, and rectangular cross-section. Below this comes the *ash-pan*, H.

Staying. As all the plates are flat, they are enabled to resist the steam pressure only by virtue of staying. The smoke tubes stay the upper portion of the tube plate. Its lower portion and the area of the throat plate are mutually connected and stiffened with screwed stays, seen surrounding **227** and **228**, while an enlarged view of a stay and its two plates is given in **229**. The sides and back of the inner and outer boxes are similarly united with screwed stays. The top of the fire-box is stiffened with *bridge* or *girder stays*, indicated in **227**. A more detailed drawing of a slightly modified design is given in **230**. The stays are of cast steel, and are of the *sling* type.

The holes for the rivets and for the screwed stays are all drilled after the several parts are in place, portable machines having preference. The holes for the stays [**229**] are screwed with special taps, long enough to reach from the outer to the inner plates. All this work is done by a gang of men distinct from those who make the barrels and flange the plates.

Fire-box in Vertical Boilers. This is a simple construction [**219**, E], by comparison with that of the locomotive. It is circular in horizontal section, and is therefore rolled in bending rolls. In vertical section it forms the frustum of an extremely tall cone, the amount of coning on the height of the box being from 3 in. to 4 in. only. The fire-box shell is sometimes welded, but more often riveted, frequently with a lap joint in small boilers, but always in larger ones with a butt joint, and either single or double butt straps. The fire-box crown is either a flat or a dished (convex) plate, C, flanged downwards and riveted within its shell. Cross tubes, D, are nearly invariably fitted, similar to those in Cornish and Lancashire boilers, except that they are more often parallel than coned. They lie horizontally, or at a slight angle with the horizontal. Holes have to be cut in the fire-box shell to receive these tubes.

Fitting to the Shell. In some other details of these furnaces practice varies. Sometimes the bottom end is slightly flanged outwards

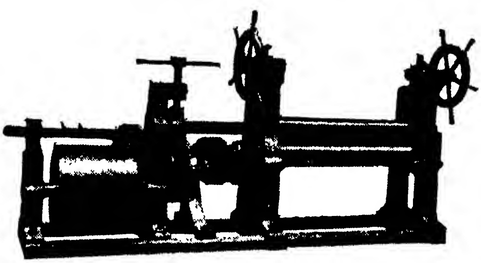


232. TUBE EXPANDERS **233.** SCREWED-BAR STAY **234.** MANHOLE **235.** STEAM DOME
236. HYDRAULIC FLANGER (Fielding & Platt, Ltd.)

237. RIVETING AND CAULKING A LANCASHIRE BOILER

to meet a foundation ring, by which the fire-box is united to the outer shell. Sometimes there is no flanging done, but the plate is plain, meeting the ring as in the locomotive [227]. Often the ring is omitted, and the flanging meets the boiler shell as in 219 and 225. The attachment to the shell around the fire-hole door generally involves a flanging outwards as at G [219]. In all but the smallest boilers the fire-box is united at intervals to the shell with screwed stays [218 and 219]. But in the smaller ones the foundation ring, the uptake, and the fire hole are the only plates where union is effected.

The Smoke Tubes. Smoke tubes [220, 221, 227, and 231] are inserted after the boiler has been riveted up, and so far completed. The holes for the tubes will have been drilled in the plates after the flanging and previously to riveting up, the positions of the holes being controlled by holes in a templet which guide the drill. The tubes therefore fit in a smooth, plain hole, in which, too, they must make an absolutely steam-tight fit. It would be improper to try to produce that fit by hammering or percussive action of any kind, therefore the tubes are squeezed by an expanding movement, and pressed tightly into their holes. Tools termed *tube expanders* are used for this work, operated by the workmen's hands. The fit is so tight that this would generally be sufficient to prevent any slip and movement of the tube plates.



238. PLATE-BENDING ROLLS

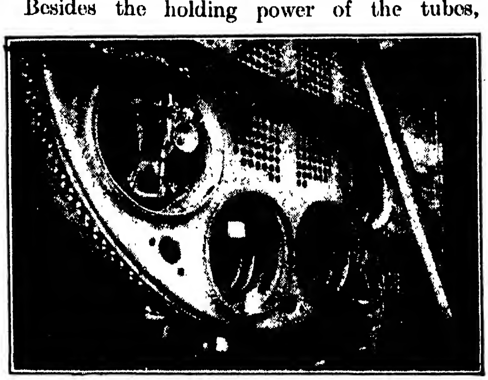
Inserting Tubes in Multitubular Boilers. When fire tubes are used, as in locomotive, and marine (Scotch) cylindrical boilers, the place of the furnace flue of the Cornish boiler [217] and of allied types is taken by the tubes and the fire-box, as in the locomotive boiler, or the furnace is shortened and the tubes return over it, as in the marine boiler [221]. These differences involve some variations in the method of working.

In the locomotive the tubes are fitted into the fire-box plate at one end, and the smoke-box plate at the other, which bound the water spaces traversed by the tubes. The fire-box plate is an integral portion of the fire-box or furnace, which also is surrounded by water spaces enclosed between it and the shell of that portion of the boiler sometimes termed the *outer fire-box* to distinguish it from the cylindrical barrel. The fire-box plates are generally of copper, and the tube plate is thicker than the rest to afford a good bearing to the ends of the tubes. Before the tubes are inserted, the fire-box is riveted into the shell with the screwed copper stays. The tubes, of brass, Muntz metal, copper, iron, or steel, are fitted generally by expanding.

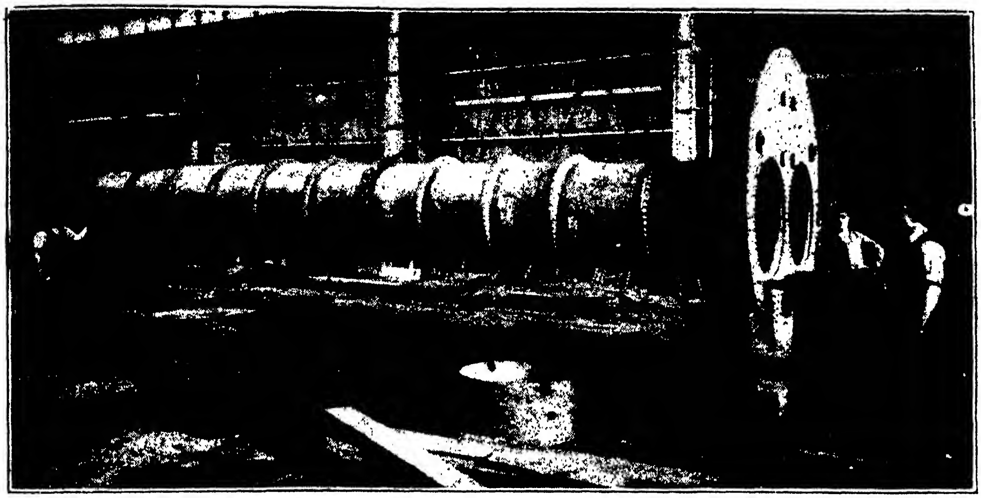
Beading and Ferruling. Expanding is generally followed by *beading*, which means turning over about ¼ in. of the end of the tube left projecting beyond the face of the plate. This is done by percussion, or by pressure, using a tool having a portion corresponding with the shape of the bead. Often in boilers other than marine boilers, the tube ends are *ferruled*—that is, short lengths of tube are inserted within the expanded ends, and also expanded therein. Fig. 231 A illustrates a tube inserted in its plate and expanded simply. At B a ferrule has been put in, and expanded within the tube; at C a tube has been beaded in addition to expansion. D shows the Admiralty pattern of ferrule, inserted in the tube with the object of preventing leakage from the tube ends, and burning, in the closed stokehold system of using forced draught. Fig. 232, A, shows how beading is frequently done by simple hammering of the beading tool against the end of the tube. It is, however, often combined with a tube-expanding tool.

Tube Expanders. The tube expanders used include two or three well-known types, the action being either the thrusting outwards of three rollers *a*, *a*, *a*, [232], within the tube, effected by the turning and thrusting of a tapered mandrel, *b*, against the inner edges of the rollers, which is the more common method (the Dudgeon expander), or by the driving outwards of segments of a ring by a tapered mandrel.

Besides the holding power of the tubes,



239. DRILLING BOILER FURNACES



240. UNITING FURNACE FLUE AND END PLATE

additional security is ensured by the insertion of a few special stay bolts, from six to a dozen in number, screwed at the ends and double-nutted [233 and 221, H], within and without the plates, or by the insertion of stay tubes, as in marine boilers. The diameter of the bottom of the threads in these must not be less than that of the body of the bolt or tube. The end plates in Cornish and Lancashire boilers are stiffened with *gusset stays* [217, J]. *Bar stays* also connect the crowns in vertical boilers [219, H].

Order of Operations. In these and other fittings, regard must be had to the sequence of operations. Diagonal stays should be riveted to shells before the end plates are brought up into position. An uptake of a vertical boiler is riveted to the furnace crown before the latter is inserted in the shell. Caulking of internal seams must be done before furnaces are inserted. Unless attention be given to these and cognate matters, awkward and impossible jobs would result.

The Combustion Chamber. This is the term given specifically to the space at the back of the furnace flues in a marine Scotch boiler [221, G]. The work is that of the plater, involving flanging, beading, and tubing, the fire-tubes bringing the products of combustion from the chamber to the front of the boiler (*return-tube type*).

241. COMBINED PUNCHING AND SHEARING MACHINE

The Smoke-box. This is the chamber into which the tubes of the locomotive discharge, being underneath the chimney. It is connected to the boiler by the front tube-plate, which is riveted to the end of the barrel with a weldless steel angle ring, encircling the end of the barrel, and shrunk on and riveted. This is flanged towards the smoke-box to receive the wrapper or covering plate, which is attached to the front plate with an angle iron. The front plate has a hole cut for the smoke-box door, which permits examination of the tubes to be made. The chimney base is made by stamping, and is riveted on the top of the covering plate over the hole cut for the purpose. The chimney is rolled and riveted down the vertical seam, and riveted to its base

Fittings. Fittings include a number of articles which the boiler-maker has to attach, and in many cases also to make. They are mostly comprised under the term *seatings*, shown on top of 217, and below H; that is, pieces of an intermediary character, which receive certain fittings, as safety valves, stop valves, blow-off cocks, etc. But manholes and domes are not intermediate, but complete fittings in themselves.

The necessity for intermediate fittings is that it would not be practicable to bolt a safety or a

stop valve directly to the boiler plating, because of the impossibility of making a close steam-tight fit in that way. And whenever repairs had to be effected or renewals made, the removal and replacement would be equally troublesome. But if a seating be prepared fitting to a boiler, and having a face planed level for the article to be mounted thereon, all trouble is avoided. Another important point is that it permits the seating to be riveted to the boiler—the best form of union suitable for direct attachments to boilers—and the actual mounting to be bolted to the seating, thereby being more readily detachable than a riveted seating.

Materials in Seatings. These seatings are made either of cast iron, or more properly of mild steel, or wrought iron. The advantages of the latter are immunity from risk of fracture, and that the edges can be caulked, which is not possible with cast iron. When cast iron is used, steam-tightness is secured by bedding them on a film of red lead, or by inserting a sheet of wrought iron (*caulking ring*) between the face of the seating and the flange of the mounting. The edge of this is then burred up with the caulking tool.

Manholes and Domes. The case of manholes and steam domes is different, because they have no seatings, but are riveted directly to the boiler. A few years ago, manholes were invariably made of cast iron, or cast steel, and then caulking rings of wrought iron were necessary. But so many accidents occurred in consequence of the fracture of the cast iron that manholes of rolled steel have superseded them [**234**]. These are made very similarly to the flue lengths of furnaces, being rolled, welded, and flanged. They are also much lighter than cast iron. Steam domes are also made by welding and flanging, though a flanged ring is often substituted [**235**].

When these and manholes are attached to boilers, the openings cut in the boiler are a source of weakness, and would be dangerous but for the practice of reinforcing the hole with a strengthening ring inserted within the boiler and encircling the hole [**234** and **235**, A]. The rivets which attach the mounting also pass through the ring and so unite the flange, the boiler plate, and the ring at once.

Geometry. There is a considerable amount of geometry involved in the marking out of plates for boiler making. Generally, this work is done by men originally boiler-makers, but whose duties are now restricted to the work of marking out (*templet makers*). The problems are those common to sheet-metal working generally. They will be found treated geometrically in Practical Geometry, and their application in Drawing for Sheet Metal Workers.

Testing. The testing of boilers is done by hydraulic pressure, generally at about double the working pressure. The boiler is nearly filled with cold water first, and then the test pressure pump, fitted with a gauge, is set to work, until the limit imposed is reached. Then the pressure is allowed to remain for an hour or more, and close observation is made to see if any leakage occurs at seams or rivets. Any such localities are marked with chalk, but are not caulked until the pressure is removed, because that would distress the boiler. If necessary, the pressure is reimposed. The steam test often follows, but it is not always insisted on. If used, it is about equal to one and a half or one and a quarter times the working pressure. Its advantage is that it tests the boiler under actual working conditions. The advantage of the hydraulic test is that no accident occurs should leakage be present —a little water spurts out, and the pressure is off.

Boiler-making is thus a trade embracing very diverse practice, which is divided between different shops and subdivided in the shops. So that we have men grouped as templet makers, planer hands, rollers, angle-iron smiths, flangers, drillers, riveters, tubers, besides unskilled labourers, holders-up, etc.

Fig. **236** shows a hydraulic flanger, pressing over the flanges of a furnace-mouth between a die on the table and one attached to the two rams. The latter are used independently for some classes of bending.

In the Shops. In the photograph [**237**] two operations are seen in progress on a Lancashire boiler, in the shops of Ruston, Proctor, & Co., Ltd., Lincoln. The men at the extreme left are working a hydraulic riveter, engaged on the end plate, while the man at the extreme right of the boiler is caulking with a pneumatic hammer, the supply pipe of which is seen lying on the ground. A small set of plate-bending rolls is shown in **238** (Francis Berry & Sons, Sowerby Bridge) driven by belt pulleys and gearing. The top roll is extended, and supported by an extra bearing, so that the roll is held level while the right hand bearing is swivelled to one side, enabling a plate to be slid off endwise, after it has been bent into cylindrical form. The two large handwheels are for raising and lowering the top roll for different curvatures. In **239** a marine boiler with four corrugated furnaces is being drilled with machine seen inside the top left hand furnace. This boiler is one of the set for the "Oceanic," constructed by Harland & Wolff.

Hydraulic riveting with a fixed machine is illustrated in **240**, the operation being that of uniting the end plate to the Adamson flue, which is supported by the overhead traveller meanwhile. This is also from Messrs. Ruston, Proctor's practice.

One of the most useful machines in the boiler shop is that shown in **241**, a combined punching and shearing machine (Francis Berry & Sons). It is driven by the electric motor seen on the top. At the left-hand end shearing is done, at the right punching, while at the centre a special pair of jaws are fitted for shearing angle irons, which cannot be done with straight blades like plates and bars.

Continued

A SHORT DICTIONARY OF TERMS IN SMITHS' WORK

ACCUMULATOR—A vessel in which water is stored under pressure for the operation of hydraulic presses.

Adamson Flanged Seam—A joint in the furnace flues of many horizontal boilers, formed by flanging the ends of the flue lengths, and riveting them together through an intermediary caulking ring.

Air Furnace—A reverberatory furnace, using the natural draught of a chimney.

Angle Bevelling Machine—A machine fitted with rolls for imparting various angles to the webs of angle sections.

Angle Iron, Angles—Rolled sections of iron and steel having two webs at right or other angles with each other.

Angle-iron Furnace—A reverberatory furnace used for heating angles.

Angle-iron Shears—Shears of V-shape, used for cutting off angles.

Angle-iron Smith—A workman whose duties are confined to the preparation of work done at the forge.

Annealing—The heating and slow cooling of iron and steel after work has been done, in order to restore ductility and homogenity.

Annealing Furnace—A reverberatory furnace used for the purpose of annealing.

Anvil—The block upon which forgings are treated. The best are of wrought-iron, welded up, and steel-faced. Many cheap anvils are produced by casting.

BANKING UP—Making up a forge fire with green coal or small coal, damped with water.

Bars—The round, or rectangular sections in which iron and steel are rolled. They are *rounds*, *squares*, and *flats*.

Beading—The burring over and rounding of the ends of boiler tubes.

Beading Tool—A drift-like tool used for beading boiler tubes.

Beak Iron, or **Bick Iron**—The conical projection of an anvil.

Bending Blocks—Blocks of cast iron variously shaped to serve for bending bars, sections, and plates by.

Bending Rolls—Machine rolls used for bending large plates in. The rolls have their axes either horizontal or vertical.

Bessemer Steel—Used in tyres, rails, and for many forgings.

Bevelled Iron—Flats having one or two edges bevelled.

Blazing Off—The burning of an oil or fat having a known flash-point, which corresponds with a temperature suitable for tempering springs and some other articles.

Bleeding—The presence of red rust on the plates of boilers, which indicates corrosion within the plates.

Blisters—A defect in plates due to the entanglement of slag or scale in the bloom previous to rolling.

Blue Heat—Corresponds with a stage between a low red and a black heat, at which, if severe work is done on steel and iron, serious loss of ductility and strength results.

Boiler—The vessel in which steam is generated by the action of heat.

Boiler Fittings—Sundry parts which have to be attached to a boiler; as doors, seatings, bridge, fire-box, &c.

Boiler Flues—The furnaces, or the brickwork, or smoke flues.

Boiler Flue Flange Drilling Machines—Machines for drilling the rivet holes in the flanges of Adamson seams.

Boiler Prover—A force-pump, with gauge, used for testing boilers by water pressure.

Boiler Scaling—Chipping the hard deposits from the interiors of boilers with a scaling hammer.

Boiler Shell—The outer body, as distinct from the furnace.

Boiler Shell Drilling Machines—Machines for drilling the rivet holes in shell plates, generally after the plates are all fitted in series.

Boiler Shop—The shop in which boilers are made. Its equipment consists chiefly of heavy machinery and forges.

Boiler Smithy—The department in which the forged work is done by the angle iron smiths.

Boiler Stays—Rods or tubes used for reinforcing the flat surfaces of steam boilers.

Boiler Tubes—Fire tubes in the locomotive type; water tubes in the water-tube type.

Bolster—A ring upon which holes are punched, and through which the burr is pushed.

Bolt Machine—A forging machine in which bolts are formed by rapid reduction in concave dies.

Borax—Used as a flux in welding steel and iron.

Bosh—The water tank in which the smith cools and quenches work.

Bossing—Forming bosses on forgings.

Bowling Hoop—An expansion ring of arched section used in furnace tubes.

Box Girder—A girder having four sides enclosing a hollow rectangle.

Bracings—Arrangements of bars in plated work which change the direction of stresses, so reinforcing otherwise weak members.

Brands—Trade marks used to denote qualities of iron and steel, and the houses from which they are sent.

Brick Arch—The arch in a locomotive fire-box which deflects the gases backward before they pass into the fire tubes.

Bricked-up Fire—A hollow fire enclosed with bricks, in which rolled sections are heated for welding, and by which they are prevented from contact with the fuel.

Bridge—The barrier placed at the back of the fire-grate in a horizontal boiler to promote combustion.

Buckle—A state of unequal tension in plates.

Bulb Sections—Bars, angles, and tees, having one edge thickened or beaded.

Bulldozer—A machine which presses work into dies by means of a reciprocating ram.

Burnt Iron and Steel—Metal which has been overheated at the forge, and injured thereby.

Burr—The piece removed by a punch.

Butt Joints—Joints that abut by their edges, and then are covered by and riveted through butt straps.

Butt Welding—The welding of joints brought into simple opposition.

CASE HARDENING—Imparting surface hardness to iron and steel by prolonged contact with bones, leather, charcoal, or ferro-prussiate of potash, at a red heat.

Caulking—Burring up the edges of riveted plates with a caulking tool to render the seams watertight.

Caulking Ring, or Strip—Wrought-iron or steel inserted in a joint to provide for caulking against.

Channels—Rolled sections the sectional form of which is that of three sides of a rectangle.

Chipping Chisel—A tool used for cutting iron and steel while cold.

Chisels—Used under the name of cold and hot setts.

Chisel Rod—Rod from which cold chisels are made, being of the same section as the chisels.

Clamps—Used for holding pieces of work temporarily.

Closing—Turning over the tail of a rivet, or the jointing of a weld.

Cold Chisel—A *chipping chisel.*

Cold Saw—A circular saw used for cutting off bars and rolled sections without heating them.

Cold-short—Signifies a condition in wrought-iron and steel in which it cannot be worked below a dull-red heat without risk of fracture.

Cold Tests—The testing of specimens of iron and steel while cold by bending and drifting them.

Collapsing Pressure—The pressure to which boiler furnaces are subjected, tending to force them inwards and crumple them.

Conical Mandrel—An appliance, circular in plan, and a conic frustum in elevation, around which rings of different sizes are bent and corrected.

Conical Tubes—The Galloway tubes used in the furnaces of many steam boilers.

DABBING ON—Making a weld by the simple contact of flat faces.

Die-Forging—Making forgings by stamping them into matrices or dies of hard metal.

Dolly—An appliance held up under a rivet head while the tail is being closed.

Drawing Down—The act of reducing portions of forgings by hammer blows.

Drift—A tapered tool used for enlarging holes.

Drilled Holes—These are used in preference to punched holes in high-class work.

Drop Forging—The practice of *die forging* when done under drop hammers.

Ductility—The capacity of metals of being extended considerably before fracture occurs.

ELASTIC LIMIT—The limit beyond which a body will not return to its original length on removal of stress.

Elongation—The amount of extension of a body under stress, generally reckoned at the point of fracture.

Envelopes—The forms of the plates required to enclose a body of any shape or dimensions.

Expanding—Specifically, enlarging the ends of fire tubes to make them steam tight.

Extras—Charges above the usual rates, made when the dimensions or shapes of plates, bars, or sections, involve increased expense in manufacture.

FAGGOT, or FAGGOTED SCRAP—Separate odds and ends of wrought-iron brought to a welding heat and consolidated by hammering.

Faggoting, or Piling—Preparing *faggoted scrap.*

Ferrules—Rings inserted in the ends of many fire tubes to protect the ends of the tubes from the action of the fire.

Fibre—The structure of wrought-iron which is developed during rolling.

Fire-box—The furnace of a locomotive or a vertical boiler.

Flanging—Producing flanges by bending over the edges of plates.

Flats—Bars, the section of which is rectangular but not square.

Flatters—A species of hammer struck by a sledge and used to impart a neat finish to plain surfaces.

Flux—Powdered sand and borax are fluxes used by smiths when making welds.
Forge—An open fire carried on a low platform, and surmounted by a hood and chimney.
Forge Tests—Rough bending and drifting tests made on specimens at the forge.
Forging—The practice of producing shapes in malleable metal at the anvil.
Fullers—Tools having convex edges, struck by a sledge and used for drawing down.
Fullering—The process of drawing down by a fuller. Also broad finishing following caulking.
GALLOWAY BOILER—A modification of the Lancashire type, having the two flues united in one at the rear, and fitted with Galloway tubes.
Galloway Tubes—Cross water-tubes of conical form.
Gap Gauge—A plate gauge having its edges notched to standard widths for measuring work during forging.
Gaseous Fuel—Used for heating reverberatory and rivet furnaces.
Girder—A beam which occurs in numerous designs.
Girder Stays—The bridge stays that reinforce the top of a locomotive fire-box.
Glut—A strip of square or triangular section used for welds.
Glut Weld—A weld made with a glut strip. It is both a butt and a V-weld.
Gusset Stay—A diagonal boiler-stay made of plate and angle.
HAMMER—A percussive type of tool which includes hand, holding-up, set, and sledge groups.
Hammerman—A smith's striker who wields the sledge.
Hammer Shaft—The handle of a sledge.
Hardening—The result of heating steel and quenching it in liquid suddenly.
Heat—Making a mass of metal hot for the purpose of forging is termed *taking a heat*.
Heater—A white-hot lump of metal placed in contact with plated work at a locality where slight correction is required.
H-Irons—*Joist sections*.
Holding-up Hammer—A hammer held under a rivet head while the tail is being closed.
Hollow Fire—A smith's fire banked round to enclose a hollow space clear of fuel.
Hollow Tools—*Swages*.
Hot Saw—A circular saw which cuts red-hot metal.
Hot Sett—A smith's chisel ground with a keen edge to sever hot metal.
Hydraulic Flanging, and Forging—Flanging and forging done on dies actuated by hydraulic presses.
Hydraulic Test—A pressure test for steam boilers.
INTERNALLY FIRED BOILER—A steam boiler having its furnaces enclosed within the shell.
Iron—Used in the form of bars, plates, and rolled sections.
JOIST SECTIONS—Rolled sections in iron and steel of the form of the letter H.
Jumping-up—*Upsetting*.
Jump Weld—A *butt weld*.
LAMINATION—A condition of iron plates the layers of which are imperfectly united.
Lap Riveting—The union of overlapping edges by rivets.
Lap Weld—A weld joint made by the overlapping of edges.
Letting down—Lowering the temperature of steel from the hardening to the tempering heat.
Levelling Block—An iron block or table on which plates are levelled by hammer blows.
Limiting Dimensions—The maximum dimensions in which bars, plates, and rolled sections are manufactured.
MALLEABLE IRON—Wrought iron.
Mandrel—A bar of round or other section around which an eye or ring is bent or corrected.
Mates—The men who work together, as the smith and his striker.
Monkey—A kind of heavy hammer suspended and swung by a rope.
Multiple Machines—Machines which embody provision for punching or for drilling a number of holes simultaneously.
OLIVER—An old-fashioned hammer operated by a treadle and spring pole.
Overall—An aggregate dimension, the sum of a number of smaller ones in series.
PAN HEAD RIVET—One the head of which has the section of a conic frustum.
Pendulum Hammer—A monkey.
Piling—Fagotting.
Planed Edges—These are adopted on high-class work to ensure smooth edges and good fitting.
Plate Furnace—A reverberatory furnace.
Plate Gauge—A notched gauge for measuring the thicknesses of plates.
Plates—Rolled material in which the length and width greatly exceed the thickness.
Plating—The working up of plates into girders and boilers.
Porter Bar—An extension on a forging, held in the hands of the smith.
Punch—A tool used for driving a hole through a forging.
QUENCHING—Thrusting heated steel into water or oil to effect hardening or tempering.
RED HEAT—Denotes the colour as seen in a dull light, as the shadow of a forge or wall.
Red-shortness—A condition in which iron and steel cannot be worked at a red heat without fracturing.
Reduction of Area—The diminution in cross section which takes place at the point of fracture of a bar subjected to tensile stress.
Reverberatory Furnace—An arched furnace in which work is heated by incandescent gases apart from contact with the fuel.
Rivet—A means of union between two or more pieces, effected by enlargements at both ends of a parallel shank, or pin inserted through a hole.
Rods—Bars of iron or steel of various small sections.
Rolls—Machines used either for bending plates to curves or for flattening them in true planes.
Rounds—Bars of circular cross section.
SAND—Used as a flux in welding wrought-iron.
Sawing—Rolled sections are sawn to lengths with economy of material and time, and the advantage of leaving smooth ends.
Scale—The incrustation that forms in steam boilers.
Scaling—Chipping off boiler scale with a chisel-like scaling hammer.
Scarf Weld—A lap weld in which the edges in contact are sloped or tapered.
Seam—A lap joint, or a flanged seam in a furnace.
Seating—An intermediate fitting on a boiler shell to receive a fitting or mounting.
Sections—Non-plane forms in which iron and steel are rolled.
Setts—Smith's chisels.
Sett Hammer—A broad hammer which is struck by a sledge.
Shearing—Cutting off iron or steel with a scissor-like action.
Sheets—Manufactured materials of large area, but thinner than plates, or below ¼ in. in thickness.
Ship Plates—The commoner kinds of manufactured steel plates.
Shrinkage—Allowance for shrinkage of forgings has to be made in smith's dies.
Sketch Plates—Plates cut to special shapes at the steel works and for which extra prices are charged.
Sledge—A heavy hammer having a long handle to permit of swinging it round in a circle.
Snap—A steel die used for imparting a neat finish to rivet tails.
Snaphead Rivet—One having a head semicircular in section.
Squares—Bars square in cross section.
Stays—Used for stiffening the flat plates of boilers.
Stay Tap—A long tap used for screwing holes in fire-boxes.
Stay Tubes—Smoke tubes which also fulfil the function of stays.
Steam Hammer—Used largely in the heavy work of the smithy.
Steel—Mild steels, or those low in carbon, are used by smiths. They include Open Hearth and Bessemer products. Carbon steels are chiefly used for cutting tools.
Swage Block—A rectangular block containing numerous bottom swages, with holes for bending.
Swages—Tools for imparting shapes to forgings. Called top and bottom tools.
Swaging—Drawing down.
TEES—Rolled sections having the form of the letter T.
Telescopic Plating—Relates to cylindrical boiler-shells the rings of which are conic frustra.
Tempering—Hardening carried to a certain stage only, less than the maximum possible.
Temper Tests—Tests made on hardened materials to ascertain their ductility and strength.
Templet—A strip, plate, or framing used for marking out work from.
Templet Maker—A boilermaker whose duties are restricted to the preparation of templets.
Thinning—Corners of boiler plates are thinned where adjacent plates overlap.
Tongs—Used in various forms at the forge and power hammers.
Tongue Joint—A V-joint made for welding.
Tube Expander—An appliance used for tightening the ends of smoke tubes in their tube plates.
Tubing—Inserting tubes in boilers.
Tuyere—The opening through which blast is delivered to a forge.
UNITED INCHES—The total section in square inches of a rolled angle, channel, joist, or tee.
Upending—Turning a bar into a position with its axis vertically.
Upsetting—Enlarging a portion of a bar by jumping it endwise.
VEE WELD—A weld joint in the shape of the letter V.
WASHING-OUT—Periodical cleaning of boilers with a jet of water.
Welding—Making joints between heated metals and alloys without any cementing materials or extraneous means of union.
Wrought Iron—A comparatively pure iron prepared by puddling.
YORKSHIRE IRON—The purest brands of wrought iron, prepared in Yorkshire
ZEDS—Rolled sections having the shape of the letter Z.

GOOD FOOD—HEALTH'S FIRST LAW

The First Law of Health. Chemical Composition, Classification and Uses of Various Food-stuffs. Advantages of a Mixed Diet. Food Accessories. Meat

Continued from page 3050

By Dr. A. T. SCHOFIELD

IN entering upon this second division of our section; we leave the high and broad general principles of health which we have hitherto been considering for the smaller and yet more practical matters of eating and drinking and clothing, and propose now to consider the application in detail of the *first law of health—good food.*

The First Law of Health. This is a subject near to the heart of every true Englishman, and rightly so; for is it not one, if not the sole, corner-stone of health? The object of all food is to repair the waste of the tissues incessantly going on during life, which, we must ever remember, consists in ceaseless metabolism, or destruction and repair. The food taken is consumed in moving and heating the body, and just as it is important for boilers to burn good coal, so in the human economy is it essential for health to have good food.

This, then, being the great general purpose for which we eat, we may further divide *food-stuffs* into two great classes of flesh-formers and body-warmers. Really, the division should be threefold—*flesh-formers*, or repairers of used-up tissue; *body-warmers*, to be burnt up to heat the body; and *body-workers*, to be consumed in mechanical work.

Broadly speaking, there are four sorts of food-stuffs which fulfil these objects. The flesh-formers are mainly the *meats* and *salts*; the body-warmers are mainly the *fats*; and the body-worker, the *starch* or *sugar*.

If these foods are taken in the right proportions the first law of health is fulfilled, but the proportion is important. If we eat too few flesh-formers and too many body-warmers and workers, we get fat and feeble. If we eat too few body-warmers and workers, and too many flesh-formers, we get lean and lively.

It will be observed that of these four foods, *two*—the meat, or nitrogenous, and the fat—are principally *animal*; *one*—the starchy—is mainly vegetable; and *one*—the salt—is *mineral.*

Chemical Constituents of Food. Furthermore, inasmuch as the first two—meat and fats—are derived from animals that are vegetable feeders, we may say that *three-fourths* of the food-stuffs are ultimately of *vegetable origin*, and one-fourth only is mineral, and of that a minute quantity suffices. So we sum up by saying all human food is directly or indirectly *vegetable*, save a small amount of minerals in salts and water. Turn now to the chemical composition of these four, and we shall find ourselves confronted by a quartette of letters—C, O, H. N, or *carbon, oxygen, hydrogen*, and *nitrogen.* Of these the essential body-warmer is the solid carbon or coal, and the essential flesh-former is nitrogen—an inert gas, which nevertheless is an indispensable ingredient in the composition of every living thing on the face of the earth. Let us look at the four for a moment.

Carbon. This is the fuel of the body, as it is of all the earth. It is *the* body-warmer and body-worker. Two of the food-stuffs really depend upon this element—one vegetable, the other animal. The one is starch—flour, sugar, etc., which forms so large a proportion of our food, and carries on all the mechanical work of the body by giving out as it is needed the necessary force for this purpose. Fat, butter and cream, the other food, keeps up the heat of the body, and where this is difficult to maintain, as in Arctic regions, during the long winter, such enormous quantities of this food-stuff are consumed as to well-nigh form the whole dietary. Not only so, but being eaten to keep the lamp of life burning, and not for greed, the whole of it is digested, which is a feat so remarkable as to be wholly inexplicable did we not know the extraordinary influence of the mind over the body at times of emergency, making it do well-nigh what it likes. One quarter of the amount of fats in ordinary life would prove far too much for the digestion. The wonder of such a consumption will be better appreciated when the real difficulties in the way of the digestion of fat are understood from the article on digestion in the section on Physiology.

Oxygen. This is a gas, as are the other two; our principal food elements consist, therefore, of one solid (carbon) and three gases.

Oxygen is the *breath of life*, and though it enters really into all we eat and drink, we derive our principal supply of it from the air through the lungs, rather than from the food through the stomach.

Consider for the moment these two, which, separately or combined in certain proportions, are the very essence of life foods, and yet, combined in another proportion—CO_2 (carbonic acid gas or carbon dioxide)—form a poison, a destroyer of life, a product of decomposition, breathed out of the lungs at every breath.

Hydrogen. This again, though forming a part of starches, sugars, fats, etc., is one constituent of *water* (H_2O), of which by far the greater part of the body is composed. *Without water* there can be no life; any tissue that dries dies. Hydrogen, therefore (in combination with oxygen), may be taken to represent principally *the fluids of the body.*

Nitrogen. This inert gas is *the* essential element in all life. It forms a great part of the body-cells themselves, and even serves as food to repair such waste of these cells as is perpetually going on. Nitrogen is found principally in animal food, whether meat, fish, flesh, or fowl. It also occurs in smaller quantities in grain, corn, beans, peas, etc., and is, too, the great agent in forming flesh.

Speaking generally, then, we may say: Carbon, as fats, butter, etc., is for the *heat of the body*; Oxygen, as air, is for the *breath of the body;* Hydrogen, as water, is for the *liquids of the body;* Nitrogen, as meat, cereals, beans, etc., is for *the repair of the body*.

In addition mineral food is required, such as salt.

The source of our supply of these four elements is full of interest. The oxygen and hydrogen we need not trouble about, as they are supplied to us *ad lib.* in air and water. Nitrogen exists also in enormous quantities in the air; and could we assimilate it—that is, receive, retain, and use it in the body as a gas—the whole food problem for the world, and especially for the poor, would be solved. As it is, we cannot take it raw, but only in expensive compounds or food-stuffs, which are the great expense of our dietaries. If we could use nitrogen from the air, we breathe enough into the lungs in one minute to equal the whole food supply of this element for the day. But we *cannot*, and so we are here absolutely dependent, as we have already shown, upon the vegetable kingdom, which can alone store up nitrogen in the form we can eat it; for not only can we not take it raw as a gas, as we do oxygen, but we cannot even use it from an inorganic compound, such as ammonia (NH_3), as we do hydrogen from water (H_2O). It must be in an *organic compound*, and we should all perish for want of it were it not for the labours of the vegetable kingdom; for even if we eat animals, they owe their flesh and blood to vegetables, like ourselves. On the silent and incessant labours of this lower world in storing nitrogen for us in a form we can take, the very existence of the animal kingdom depends.

Vegetable Diet. The vegetable world, we know, *can* obtain its food from inorganic and simple substances. It draws the nitrogen from the soil, and the *chlorophyll* (green colouring matter in leaves) causes the water it draws up from the roots to unite with the CO_2 of the air and form starch ($6CO_2 + 5H_2O = C_6H_{10}O_5$) (6 molecules of carbonic acid and 5 of water form 1 molecule of starch). Vegetables build up compound organic forms from simple inorganic ones, thus storing up force for animals to unbuild and expand, by adding more (or by combustion), with the formation once more of carbonic acid and water. Hence the vegetable process is called *anabolic*, and the animal *katabolic*, *metabolism*.

The vegetable kingdom is an essential link between the inorganic world and the animal kingdom. Animals must have, as food for producing internal warmth, those compound organic bodies that vegetables now spend their lives in making, in the same way as the vegetable kingdom laid up long ago stores of coal to provide external warmth for us, by its slow combustion into gas, water, and ash. The fire within and the fire without come from the same source. Animals do not, however, dissipate at once all the energy they get; part is used to build up the still more complex forms of animal proteids; so that when these are eaten (animal diet) they provide a still greater amount of stored-up force. Animal diet, therefore, though expensive, is more stimulating than vegetable.

Wasted Food Material. Amongst the dreams of men concerning these subjects, none is so beneficent or far reaching as that which pictures us deriving this great and expensive element nitrogen freely from the air. It is really an exasperating thought to remember that thousands die of starvation, who die actually taking every minute into their bodies (by the lungs) food they have no power to retain. It is worse than men dying from thirst on the ocean. So many wild dreams of past years are to-day the commonplace of science, that he would be both bold and rash who would affirm that nitrogen as food may not yet be supplied without cost, just as hydrogen and oxygen are now.

The other element for which we have to pay is carbon. Unlike nitrogen, it can be consumed in a raw state; for coal has been eaten, diamonds have been crushed and drunk, and lead-pencils sucked, but we cannot assimilate carbon well and easily; and practically, as its inorganic compound CO_2 (carbonic acid gas), is a poison to man, we have to depend for it on the organic compounds of starch and sugar, the results of the labours of the vegetable world. So at present we pay heavily for our carbon and nitrogen, getting our hydrogen and oxygen free.

Before leaving these preliminaries let us make quite clear to our readers the life cycle that we spoke of in the first chapter.

Carbon, oxygen, hydrogen, nitrogen, are the elements of the inorganic compounds *ammonia*, *air*, and *water*, and these are built up by the vegetable world into *starches*, *fats*, and *proteids;* we eat them and build them up further into *flesh* and *blood*. Then by that metabolism, or ceaseless change, of which life consists, they are soon unbuilt again right down to *ammonia*, *water*, and *carbonic acid gas*, the compounds of the four elements with which we began.

The Ideal Diet. Of these four great food-stuffs man for subsistence requires every 24 hours ¼ lb. proteids, such as meats; ½ lb. carbohydrates, or starches; ⅛ lb. hydrocarbon, or fats; ½ oz. salt; and 2 quarts of water, besides air. In other words, 1 lb. of dry food daily, 5½ lb. of water, and 1¾ lb. of oxygen in air.

It must be remembered that most food is more than half water; so that about 2½ lb. of *ordinary* food makes 1 lb. of *dry* food.

The above diet is roughly represented by ½ lb. steak, 1 lb. each of bread and potatoes, 2 oz. butter, a little salt, 1 pint of milk, and a quart of water.

Functions of Food-stuffs. But fats and starches are formed of carbon, hydrogen, and oxygen, and, as they contain no nitrogen, they are not alone sufficient to sustain life. They differ, too, in their use. The sugars and starches only give out force by the combustion of the *carbon* in them (with oxygen); they give energy rather than heat, and hence are principally of use for *mechanical work.* The fats and oils burn both the *carbon and the hydrogen,* and this produces great heat; they are thus used for *warming the body;* but they are harder to digest, the easiest forms being those of cream and butter.

The mineral food is principally used to dissolve the rest. Both salt and water are great solvents of proteids, hence salt is so useful with eggs and meat.

Of the flesh formers, as may be supposed, about *twice as much* is required (in proportion to the body weight) during growth as in adult life.

Excess of starch and fat foods is easily stored up in the body and in the liver; but excess of proteids *cannot* be stored up, and they circulate in the blood and cause many evils.

The amount of body-warmers required decreases slightly from birth to death; that of body-workers varies immensely with the work done. In hard work more than double the ordinary amount is required.

Sources of Food-stuffs. Having thus glanced at the composition of food-stuffs, we will consider their variety and their sources.

They fall into two classes—inorganic, or mineral, and organic. To the former belong:

1. SOLIDS. *Salts,* principally common salt, also phosphates of lime and iron, and others.

2. LIQUIDS. *Water,* absolute amount needed 5½ lb. daily.

3. GASES. *Oxygen,* about 7,000 grains, or 1⅞ lb. daily.

No animal organism can live without water, which is continually changed every day, so that Hoppé Seyler's saying is true that "all organisms live in running water."

Organic foods are subdivided into animal and vegetable, and these both include proteids, or nitrogenous foods, and non-nitrogenous foods.

1. ANIMAL PROTEIDS, derived from milk, eggs, meat, fish, fowl, etc.

2. VEGETABLE PROTEIDS, first discovered in 1838, derived from all cereals—wheat, barley, oats, rye, maize, etc., and from all legumes, such as peas and beans of all sorts. Pea cheese, as made by the Chinese, is an excellent substitute for meat, while macaroni, vermicelli, etc., made by the Italians, is the strongest vegetable proteid food from cereals.

Advantage of a Mixed Diet. Before 1838 it was believed that all nitrogen as food must be derived from meat, and hence vegetables occupied a very secondary place. Since then it has been found that so many sorts of grain produce proteids in such large quantities that it is perfectly possible to keep the body in health *on vegetable food only.* There is, therefore, no ground for the great prejudice that still exists against a vegetable diet in the minds of many Englishmen, and although it is probable that we were never intended to be exclusively vegetarians, the fact remains that at present we eat too much meat, and the introduction of proper vegetable food into the working homes of England would prove a powerful source of both health and happiness.

The Source of Proteids. With regard to proteids, we may remark that nitrogen is always being lost, and an animal without this food must waste, and could only exist at all by feeding on itself. It is found in the *gluten* of wheat, in the *albumen* of eggs, in the *casein* of milk as well as in meat, in the *fibrin* of blood, the *syntonin* of muscle, the *gelatin* of connective tissue, and elsewhere. It is also found in the flesh of all other animals, fish, shell-fish, birds, etc. Proteids (with minerals) can sustain human life alone for a short time, but they are such a wasteful diet that they put a strain on the digestive organs so enormous that they cannot long sustain it. Proteids contain 3½ parts of carbon to 1 of nitrogen, whereas we shall see that the daily waste, and therefore the daily food, requires to be in the proportion of 15 to 1. To get enough carbon, therefore, four times as much meat (and nitrogen) must be consumed as is necessary, enough nitrogen for the daily supply being furnished by 1 lb., whereas it takes 4 lb. to furnish the amount of carbon. When we see that, instead of 4 lb. of meat, ½ lb. of fat or 1 lb. of sugar gives the needed amount of carbon, the advantage of a mixed diet is obvious.

Carbohydrates or Starch Foods. Non-nitrogenous foods include (A) Carbohydrates, or starch foods, and (B) Hydrocarbons, or fat foods.

1. ANIMAL SUGARS, derived from milk and honey. It is not a little remarkable that milk is practically the only source of animal starch or sugar, this being otherwise almost an exclusive product of the vegetable kingdom.

2. VEGETABLE STARCHES AND SUGARS. All grains, beans, and vegetables; various sugars—cane, beet, grape, and malt sugars. Alcohol is also a carbohydrate.

Animals fed on these alone have to consume their own tissues to get the nitrogen required. Dogs fed on sugar and water remain healthy a week, then get ulcers on the eyes—as Hindoos do who live solely on rice—and die in a month.

The essential food of life is, therefore, the *nitrogenous;* the accessory, *the non-nitrogenous.* Referring to these as body-workers, it was long thought by the greatest chemists, such as Liebig, that the body work was really done by the proteids. The proof that it is not is as follows: The *waste product* that is found in the body when *proteids* are used up (oxydised) is *urea;* while the *waste product* of the combustion of sugars (carbohydrates) is *carbonic acid gas.* Careful experiments were conducted by Pettenkofer and Voit, which succeeded in proving that the amount of urea produced in twenty-four hours did *not* vary in proportion to the amount of work done, but that the amount of carbonic acid always *did.* This showed conclusively that work used up the carbohydrates, and not the proteids

The Hydrocarbons or Fat Foods. The Hydrocarbons or Fat foods are:

1. Animal Fats. Butter, dripping, suet, lard, cod-liver oil, cream, etc.
2. Vegetable Fats. Olive oil, linseed oil, castor oil, cocoa butter, etc.

Both these and the carbohydrates are composed of carbon, hydrogen and oxygen, but the essential difference between them, to which they owe their different names and properties, is due to the fact that in the latter the hydrogen is just twice as much as the oxygen—that is, *in the proportion to pure water* (H_2O), and hence they are called hydrates, and have no free hydrogen left to burn, as in the case of sugar ($C_6H_{12}O_6$) for example.

Hydrocarbons, on the contrary, have a great *excess of hydrogen* over the carbon, and hence have plenty that is free to burn. $C_{10}H_{18}O$ is a fat formula, and if we deduct 2 parts of H to form water with the oxygen we still have 16 parts of hydrogen left free to burn, besides 10 of carbon.

Besides the above, there are food accessories and beverages. The former include fruit and condiments.

1. Fruits. These contain various vegetable acids, such as tartaric in grapes, citric in lemons, malic in apples, oxalic in rhubarb, acetic in vinegar, all of which are good for the blood, and assist to keep it alkaline.
2. Condiments and spices contain various aromatic bodies, which act as digesters.

Of beverages we shall speak later on, and need not discuss them here.

So far, we have been considering food-stuffs, or food materials and the chemical elements of which they are composed. It is our duty now to look at the Foods themselves, and we shall find it a subject of much interest.

Let us take them in four divisions:

1. Animal Foods.
2. Vegetable Foods.
3. Accessories, Condiments, and Spices.
4. Manufactured and Tinned Goods.

Among the animal foods, many of our vegetarian friends will, no doubt, be surprised to see milk, butter, and cheese, which they have long treated as vegetable. We begin with meat.

Animal Foods

Meat. This averages in composition, three-quarters water, one-fifth proteid or nitrogenous food, and one-twentieth fat. A whole ox is one-third fat, a pig one-half.

Meat compares with bread thus, as regards the food-stuffs it contains (in 100 parts):

Food-stuffs.	Meat.	Bread.
Proteids	20	6
Starches	—	48
Fats	5	1
Water	75	45

Or, roughly speaking, 1 oz. of meat is three-quarters water and one quarter proteid, and bread is half water and half starch. Meat has no starch, and bread very little proteid.

Good meat is firm, elastic, moist (not wet), marbled, bright red flesh (not pink or purple), with the fat firm and a yellowish white. This meat does not shrink much in cooking. The best beef is from oxen five or six years old.

Diseased meat is dark, wet, and tasteless; decomposing meat is pale, flabby, with a bad smell and an alkaline reaction, whereas fresh meat has an acid reaction.

Mutton is the most digestible meat, and the wether mutton is best. Ram mutton is coarse and rank.

Pork is harder to digest, unless pickled. Ægineta, who was a great authority on food in the Middle Ages, says: " Among quadrupeds, swine's flesh is more nourishing than any other, because it is most like human flesh, as those have declared who have tasted human flesh by mistake. That from sheep supplies bad juices, and that from oxen forms melancholic humours."

Meat is subject to anthrax (carbuncle), foot and mouth disease, farcy, and glanders, all of which are transmissible to man. Even in diseased meat, most of the poison is destroyed by thorough cooking, but not necessarily all of it; because, though the bacteria may die, some of the toxins or poisons they make may still be in action.

The only real safeguard is to eat sound meat. Tuberculous meat also should *not* be eaten, though it is still disputed whether consumption can be transmitted from animals to men. Sheep have parasites (1 in. long.) in the liver, called flukes, which are killed by cooking. Beef and mutton are also afflicted with other small parasites. Pork is liable to the measles (*not* the same disease as human measles), the small parasites of which are very numerous. There may be 100,000 in a square inch of muscle.

It is most important, therefore, that the meat eaten should be sound in every way.

Method of Preservation. Meat is *preserved by cold.* It is not often frozen now (temperature below 32° F.), but kept 3 degrees above (35° F.), which, while it keeps the meat in perfect condition, does not render it hard and dry like the older method. Beef, mutton and lamb are all thus brought in perfect condition from Australia, New Zealand, and America, in ships fitted up for the purpose. Meat can also be preserved by high seasoning, as in sausages; by drying in strips as is done in South America; by curing, as in the case of pork; by smoking, or, again, it can be salted, or canned.

Continued

FISHES IN THEIR NATURAL COLOURS

continued from page 3072

SHELL-FISH AND SEA SHELLS

Snails and Slugs. Beautiful Shells. Sea Butterflies. Limpets. Cuttlefishes. Squids. The Octopus. Shell Incubators

By Professor J. R. AINSWORTH DAVIS

We have now surveyed the various groups of backboned animals, and must next proceed to the consideration of the infinite variety of forms collectively known as backboneless animals, beginning with the highest of these and concluding with the lowly microscopic creatures popularly termed Animalcules. It will be convenient to start with shell-fish or molluscs (*Mollusca*), which include cuttlefishes, snails and slugs, cockles, oysters, mussels, and others.

Shell-fish. Molluscs are soft-bodied creatures, not divided into successive rings or segments provided with limbs (like lobsters, centipedes, insects, etc.), and very commonly protected by a calcareous shell. The under side of the body is thickened into a fleshy "foot," by which locomotion is effected, and there is typically a well-marked head. These features are well seen in 380, which represents the edible or Roman snail (*Helix pomatia*), looked at from above.

380. ROMAN SNAIL
a. Feeler *b.* Head *c.* Edge of foot *d.* Back of foot

The Mollusca are divided into five classes: 1. Snails and Slugs (*Gastropoda*). 2. Cuttlefishes (*Cephalopoda*). 3. Tusk Shells (*Scaphopoda.*) 4. Bivalves (*Lamellibranchia*). 5. Mail Shells (*Protomollusca*).

Snails and Slugs. In a typical snail [380] the shell is of spiral form, and the body of the animal can be completely withdrawn into it as a means of defence. The under side of the foot is a flat sole-like expansion, from which a kind of slime exudes, and by waves of muscular contraction the animal is able to glide along a smooth surface, as everyone must have noticed in our common garden pest. The mouth is provided with a singular rasping organ, by which particles are scraped from the food. It consists of a projection rising up from the floor of the mouth, over which is stretched from front to back a horny ribbon (*radula*), studded with rows of minute teeth, by which rasping is effected.

381. ROCK SHELL

382. MITRE SHELL
e. Canal *f.* Notch

383. COWRY

A great variety of snails live in the sea or between tide-marks, and most of these breathe by means of a plume-like gill (sometimes by two) contained in a gill cavity placed far forward on the upper side of the body and roofed by a membrane, the mantle, which helps to make the shell. The purified blood flows into a two-chambered heart, which pumps it over the body. Some sea snails are pure vegetarians, while others are predaceous and highly carnivorous. In the former—*e.g.*, common periwinkle (*Littorina littorea*), the opening or mouth of the shell is bounded by a continuous curve, and is said to be entire. But in carnivorous types there is a notch or canal [381, 382, 383] for the lodgment of a tube (*siphon*) by which pure water flows into the gill cavity, the reason being that an active flesh-eater requires more perfect arrangements for breathing than a sluggish vegetarian. Some of the carnivorous types prey upon other shell-fish, using their rasping organs for boring through the hard covering; a procedure which may be aided by the secretion of acid, for dissolving the calcareous matter.

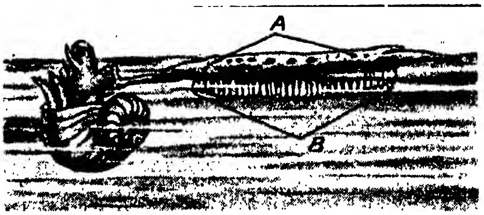
Shells. The shells of sea snails are often of great beauty, and three types from among a bewildering variety have been selected for illustration—namely, a rock shell (*Murex*) [381], a mitre shell (*Mitra*) [382], and a cowry (*Cypræa*) [383]. A smaller species of the last is used in Africa as a substitute for money. Large sums have been given by collectors for shells of unusual beauty or rarity, and £50 has been paid for a single specimen of a species of cone shell (*Conus*). The helmet shells (*Cassis*) are made up of differently coloured layers, and have been largely employed for the carving of cameos.

384. CARINARIA
a. Head *b.* Foot *c.* Shell

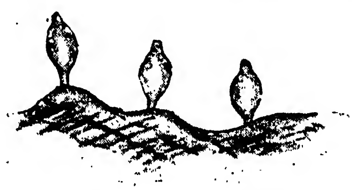
385. SEA BUTTERFLY
a. Fins

Photographs by Professor B. H. Bentley

Sea Butterflies. A great many sea snails have given up the creeping mode of life and taken to swimming at or near the surface, and this has led to much modification in structure. A comparatively large type of the kind is carinaria [384], in which part of the foot is altered into a flattened fin, that moves from side to side and propels the animal as it lies on its back. The shell is reduced to a little cap, by which some of the more delicate organs are protected. Part of the floating population of the sea consists of little sea snails (*Pteropods*) which are still more profoundly modified, and on account of their beauty are popularly called "sea butterflies." They move by flapping a pair of delicate muscular fins, and may either possess a delicate glassy shell, or be entirely devoid of any protective covering [385]. So abundant are these little creatures that they constitute the chief item in the diet of the huge whalebone whales.



386. VIOLET SNAIL WITH EGG-RAFT
a. Raft *b.* Egg-capsules

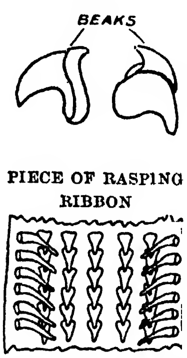


387. EGG-CAPSULES OF PURPLE SHELL

The sea slugs are descended from sea snails by reduction or complete loss of the shell, with elongation and flattening of the body [391]. Many of them are of elegant form and beautifully coloured.

Sea snails and their allies are protected in a variety of ways from their enemies. The shell is to be regarded as the primary means of defence, and in average cases the animal can withdraw entirely into this house. In many species a hard plate attached to the upper side of the back end of the foot (*operculum*) serves as a sort of front door. This plate is familiar to eaters of periwinkles, who use it as a purchase for the pin by which the delicate morsel is extracted from its stronghold.

388. PEN OF SQUID

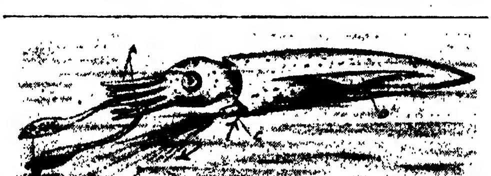


389. RASPING ORGANS OF CUTTLEFISH

Limpets. Tactics of an entirely different kind are resorted to by the sluggish vegetarian limpet (*Patella vulgata*), which abounds on the 'tween-tide rocks all round our coasts. The shell has here lost its original spiral form, and assumed a conical shape [396]. When threatened by the attacks of other animals, or in danger of being washed off the rock by the tide, the limpet holds on firmly by means of its strong oval foot, and pulls down the shell over its body, being then completely hidden from view. Like some other members of its group, it possesses a strong sense of locality, and selects a particular spot upon which to roost, wandering out from this home for two or three yards to browse on sea-weeds, and returning when threatened by the wash of the tide. In course of time, the action of shell wear out a distinct oval "scar," the polished surface of which makes holding on a comparatively easy matter.

An interesting feature is that many of the sea snails are protectively coloured, resembling their surroundings so closely that it is difficult for their enemies to see them, and certain species which live on branching corals of different kind, vary in hue according to the nature of their home. Those which swim at the surface of the sea are transparent, often with a bluish , and are thus rendered very inconspicuous. Many sea slugs, on the other hand, are distinguished by the extreme brightness of their tints, and are exceedingly conspicuous in consequence. This is a case of warning colouration, associated with a disagreeable taste, and it has been found that fishes usually reject them as food. Cone shells can inflict poisonous bites.

Care of Eggs. There are often arrangements for the protection of the eggs among sea snails and slugs. Sometimes they are imbedded in a sort of jelly which adheres to the various objects, or in a band of similar substance strengthened perhaps by sand grains, or, still more commonly, they are enclosed in hard protective capsules, as in the purple shell (*Purpura lapillus*) [387] and whelk (*Buccinum undatum*). In a few cases the egg-capsules are sheltered within the parent shell until such time as the eggs hatch out. A very elegant device is seen in the beautiful violet snail (*Ianthina*), which lives in the open sea. This creature constructs a buoyant raft of hardened slime mixed with air bubbles, and to the under side of this the numerous egg-capsules are attached [386].



390. SWIMMING SQUID
a. Arms *b.* Tentacles *c.* Funnel *d.* Fin

From the egg of a sea snail or slug a delicate little transparent larva hatches out [395], which

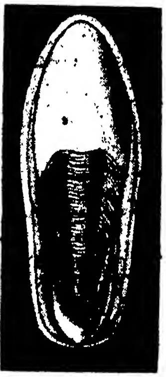
swims about by means of a kind of flap projecting from the head. Its individual chances of survival are very slender.

Land Snails. Land snails have no doubt descended from aquatic ancestors, but have lost their gills and converted the gill chamber into a sort of lung for breathing ordinary air. The Roman snail already figured [380], shows very clearly the "lines of growth" upon the shell, which mark the successive additions made as the inhabitant gradually increased in size. This particular species, not infrequent in south-east England, and common on the Continent, is said to have been introduced into this country for culinary purposes by the Romans. Under the name of "escargot" it figures in French cookery, and eaters of this and other species are not unknown in Britain, partly because there is a popular notion that they are a cure for consumption.

391. SEA SLUG *a.* Feelers *b.* Head *c.* Foot

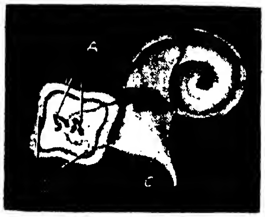
Land snails are very tenacious of life, and, under favourable circumstances, can remain dormant for a very long time, under which conditions the mouth of the shell is closed by a partition of hardened slime. Land slugs have only a small shell or no shell at all [392], and the abundant slime which exudes from their skins prevents them from being dried up. Land snails and slugs usually deposit their eggs in the ground, afterwards covering them with earth. The young resemble their parents from the time of hatching.


392. LAND SLUG *a.* Opening of lung


393. CUTTLE BONE

Some of the lung-snails have taken to living in fresh water, and when these are kept in an aquarium they may be seen to come up to the surface to get air from time to time. The common pond snail (*Limnæus stagnalis*) [394] is a familiar form, which may often be seen, shell downwards, crawling along the surface film where air and water meet. Its eggs are deposited on stones or water plants, imbedded in a gelatinous mass.


394. POND SNAIL


395. LARVA OF SEA SNAIL *a.* Feelers *b.* Swimming flap *c.* Foot


396. LIMPET SHELL

Cuttlefishes. These are highly predaceous marine molluscs in which a part of the foot has wrapped round and closely fused with the head. This region is drawn out into eight arms and two long tentacles in the cuttlefishes and squids [390], into eight arms only in the poulpe (*Octopus*) [402] and its allies. The inner sides of the arms, and of the swollen ends of the tentacles when these are present, are studded with adhesive suckers which are able to hold firmly to prey. Arms and tentacles alike can be stretched out at will to a relatively considerable distance.

The mouth lies in the centre of the arms and is provided with a powerful parrot-like beak, within which is a rasping organ like that of a snail [389]. A large complex eye is situated on either side of the head, and on the posterior side of the body there is a large gill cavity, containing two plume-like gills. The water entering this cavity makes its way through a slit and passes out again through a tube known as the funnel.

The most expert swimmers in the group are the slender-bodied calamaries or squids [390], which dart backwards through the water with extreme rapidity, by forcible ejection of water from the gill cavity through the funnel. An elongated internal shell or "pen," of horny consistency, keeps the body sufficiently stiff, and thus favours quick progression [388]. A triangular fin on each side helps to balance the animal.

An Enormous Squid. Some of the squids attain a gigantic size, and would appear to be partly responsible for the legend of the "great sea serpent." In one authentic case the body was 14 ft. long, the arms 10 ft., and the tentacles 24 ft., and still larger specimens have been recorded.

The common cuttlefish (*Sepia*) is relatively shorter, broader, and flatter than a squid, and the internal shell or "cuttle bone" is a broad oval plate made up of calcareous layers [393]. It is often to be seen cast up on our shores, and is employed in the preparation of tooth-powder. Scraped cuttle bone, under the name of "pounce," was formerly used to dry writing before blotting paper was invented.

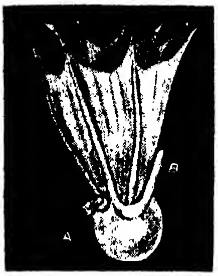
A little relative of the cuttlefish (*Sepiola*) possesses a short, rounded body, and half buries

397. SEPIOLA

itself in sand, patiently looking out for prey [397].

The Octopus. Turning now to forms with eight arms but no tentacles, such as the poulpe (*Octopus*), we find a plump, rounded body which has lost its internal shell [402]. Most creatures of the kind lurk in holes on rocky coasts, and use their sucker-bearing arms for creeping about, though they are also able to swim fairly well. Large individuals are not uncommon on the shores of the Channel Islands, and a realistic account of a combat with one of these is given in Victor Hugo's "Toilers of the Sea."

Some of the eight-armed forms have given up the creeping mode of life, and once more taken to swimming, but in a new fashion. Webs have been developed between the arms [398], the result being an umbrella-shaped expansion which propels the animal by alternately opening and shutting.



398. UMBRELLA OCTOPUS
a. Eyes *b.* Funnels

Methods of Defence. It might be supposed that the active and predaceous members of the group would need no special means of defence, but, as a matter of fact, they have unrelenting enemies such as sharks and porpoises, and ward off attacks in more than one way. As in chameleons, frogs, and many fishes, there are pigment bodies in the skin, and these are capable of contracting or expanding to bring about colour changes in correspondence with the surroundings. The arrangement is undoubtedly protective, but also serves aggressive purposes.

A sort of bag containing an inky fluid opens into the intestine near its termination, and if the attack of an enemy is pressed home the fluid is ejected into the surrounding water, clouding it for some distance. Under cover of this artificial night the mollusc is often able to make good its escape. The pigment sepia was originally prepared from the ink-bags of cuttlefishes.

401. EGG-CAPSULES OF CUTTLEFISH

The large eggs of cuttlefishes, squids, and poulpes are laid in firm capsules, which are bound together in grape-like masses [401]. Instances of maternal solicitude for these have been recorded. The young animals, when they hatch out, resemble the adult except in size. The argonaut, or paper nautilus (*Argonauta*), one of the eight-armed species, affords a striking instance of care of eggs. The male is small, shell-less, and insignificant, but the female possesses a beautiful ribbed shell, with a keel-like edge, formed by a secretion that exudes from the greatly broadened ends of two of the arms, and is not comparable to the shell of any other mollusc [399]. It is not only used as a dwelling by the mother argonaut, which grasps its ribbed exterior by her two "shell arms," but also serves as an incubator, within which the eggs pass through their development.

399. ARGONAUT *a.* Shell *b.* Animal

400. PEARLY NAUTILUS
Photographs by Professor B. H. Bentley

A Living Fossil. There is one existing member of the cuttlefish class—*i.e.*, the pearly nautilus—which differs in many ways from the rest, and may be regarded as the last survivor of a group once dominant, a sort of "living fossil" in fact. The rounded body is covered by an elegant external shell, of regular spiral shape, and a section through this shows that the older part is divided into a series of chambers by curved partitions [400]. The animal lives in the last large chamber, and as it grows, continues to enlarge the mouth of this, adding a new partition at the back from time to time. The older part of the shell is, in fact, converted into a series of gas chambers, which help to buoy the animal up and prevent the large heavy shell from becoming too much of an encumbrance. The device has not proved a great success, for all molluscs with a chambered external shell have long since become extinct, with this one exception. It has four gills.

402. POULPE
a. Funnel

Continued

MIND & THE FUTURE OF THE RACE

The "Beginning" of Mind. The Limits of Education. Natural Selection in the Sphere of Mind. The Future is the Child of the Present

Group 3
PSYCHOLOGY
9

Continued from page 2996

By Dr. C. W. SALEEBY

UNTIL Herbert Spencer published his "Principles of Psychology," in 1855, it had never occurred to psychologists to consider anything but the adult European mind as they knew it. No one had concerned himself with the savage mind, nor with the mental characters of the lower animals, nor had thought that the mind of a child constitutes an extremely important and interesting object of scientific study. The term *genetic psychology* (from *genesis*, begetting) is often applied to the whole of that branch of psychology which treats of the history and evolution of mind. Its philosophic importance transcends that of any other part of the subject.

Mind "Began" with Life. Readers of the chemistry course, where the revelations of radium are dealt with, will remember that there is reason to believe in the spontaneous development or generation of what we are pleased to call living matter from what we are pleased to call dead matter. Modern science denies that there is any such thing as vital force, and believes that life is potential in what our ancestors used to call brute and dead matter. But suppose this be granted, let us see where it leads us.

What do we find if we trace back the history of mind? Notwithstanding the opinion of Descartes, we find evidence of consciousness in the lower animals. When we say "let sleeping dogs lie," we assume that there is a difference between a sleeping and a waking dog. If we pass below the mammals and the birds, we find evidence of consciousness, though of a dull and glimmering kind, in the lower vertebrates, including even the fishes. If we then turn to the invertebrates we find that signs of consciousness are still present. If we pass down as low as the insects, we suddenly come upon a new mental world. In bees and ants and wasps, but much more markedly in the social bees and wasps than in the humble bee and the solitary wasp, we find a wonderful mental development, associated, as we should expect, with the presence of a high proportion of nervous tissue. Even so low down in the evolutionary scale we find abundant signs of mind.

Mind in Lower Forms of Life. In the subsequent course on Sociology we must find space, which is not available here, for a discussion of some of the ways in which the mental characters of these insects display themselves—in their division of labour, care of the young, obedience, the keeping of slaves, and so on.

If we pass down lower still we soon lose any such developments as these, but still we find sensation. Now, if sensation be a fact or act of consciousness, we must agree that the realm of psychology has not yet been traversed. Nor, of course, would it be logical to expect to find any point in the evolution of life above which mind was to be discerned, while below it there was none. If we make a bold step and go right down to the bacteria, there we still find sentiency or sensitiveness. If anyone questions this, let him watch a leucocyte under the microscope attacking a noxious microbe. Watch a leucocyte fighting a malaria parasite for half an hour on a warm stage in a drop of blood to which a minute quantity of quinine has been added (so as to give the leucocyte a fair—or unfair—chance), and you will not question the existence of sensation in the lowliest forms of life. Upon this you may agree, though you need not credit the stories of leucocytes who find the duel too much for them and retire, but shortly come back again with a couple of friends.

Mind in the Individual and in the Race. If, then, mind in its rudimentary forms be co-extensive with life, and if life be, in a rudimentary form, present or potential in all matter, what is the amazing conclusion to which we are led? This is where the realm of psychology becomes continuous with that of philosophy. Our business here is merely to show the relation between the two studies and the stupendous ultimate significance of psychological assertions which we may sometimes have been inclined to accept without seeing, at first, how far they will lead us.

Everyone who has made any study of biology, or the science of life, is acquainted with what is called the *recapitulation theory*, which asserts that the history of the individual is a shortened and more or less modified recapitulation of the history of the race; or, to use the phrase of Hæckel, that "ontogeny is a recapitulation of phylogeny. In the development of mind in a child, then, we expect to find the appearance and disappearance of characters which are not, properly speaking, human; and this, in point of fact, we do find. Often we address a child as "my little man," and half a century ago children were thought to be little men and women. They were assumed to have the same mental characters as their seniors. If a child showed signs of being cruel, thoughtless, selfish, or careless about cleanliness, these characters were put down to original sin or inherent wickedness, and the child was reprobated and punished. But this was really very uncharitable, and, indeed, our forefathers might have learnt wisdom from the most magnificent words that have ever been written about charity. In the course of an incomparable chapter, St. Paul says: "When I was a child, I spake as a child,

I understood as a child, I thought as a child; but when I became a man I put away childish things."

The Mind of a Child. Nowadays we see that a child is by no means a little man. We see that he has his own ways of thinking, understanding, and acting. We see that his selfishness and the like really represent mental and moral stages which are prehuman or subhuman. Regarded in the light of the recapitulation theory, the whole history of the development of a child's mind assumes a new significance. The wisest among us are therefore beginning to modify educational practice. It is being seen that, so far as the moral education is concerned, we must blame the child less and try to understand him more. While we seek to lead forth, or educate, the worthy characters, we must seek, on the other hand, as Tennyson, the poet of evolution, said, to "let the ape and tiger die."

But the present writer never deals with psychology without encountering the temptation to write a little treatise on education; and he must refrain. This at least, however, may be said—that when at last we reach a really rational education, which will provide the fittest environment—mental, moral, and physical—for the whole child, it will be upon the truths of psychology alone that our practice will be founded.

There is no room here to enter on a discussion of the moral aspects or faculties of the mind, though their importance, of course, cannot possibly be over-estimated. But, at any rate, space must be found for making one assertion, which is of the utmost importance in regard to the practice of education.

Brain Cells cannot be Multiplied. In accordance with a great law discovered by Herbert Spencer, a cell which has become so highly developed and differentiated as a nerve cell must necessarily have completely lost any power of division. No nerve cell can divide. The number of nerve cells in the brain of a new-born baby—perhaps about twenty thousand millions—cannot be increased, even to the extent of a single one, by any processes of education. Injury or disease may destroy nerve cells; no power on earth will multiply them.

It follows, therefore, that for any given individual there is an inexorable limit of psychical possibility. No amount of education, not if it were continued for a thousand years, could ever cause an Australian aboriginal, nor the present writer, nor, if one may venture to guess, the present reader, to write a "Hamlet" or a Book of Job. The potency of education is therefore limited by what is given by inheritance. This is by no means to say that any of us makes the most of his inherited possibilities, but it has a most important practical corollary. It implies that, while everyone should certainly be given the chance to avail himself of the highest types of education, yet it should be recognised that there are brains and brains. There are those who are predestined, be they educated never so long and well, never to make anything more than good farm labourers or the like. You cannot educate or draw out of any brain more than Nature has already put into it. Some day, perhaps, we shall try to adapt our education to possibilities; not, to use a very powerful and perhaps cruel image, casting our pearls before swine.

Has the Mind Reached its Limit? Since there is a curious delusion by which men think of the mind as synonymous with the intellect, some readers may have been puzzled to know how it is that in the preceding sections we have paid so little attention to the intellect, but have spent much space upon temperament, emotion, and will. This has been done of intent. In the first place, we desire to emphasise the fact that men of intellect—not psychologists—have habitually tended to over-estimate the importance of intellect. This tendency is shared by many women, who greatly admire the intellectual qualities of men. But the most important thing in the world is human nature, which is a very different thing from the human intellect, and in discussing psychology, which might have been called the science of human nature, it has been our purpose to interest the reader, if possible, rather in the fundamental facts of character and in the circumstances that determine action, rather than in questions of thought. Nevertheless, it is no purpose of the present writer to depreciate the intellect, and if it were so, the SELF-EDUCATOR would be a most ill-chosen medium for his purpose. It has, fortunately, been found possible for us to consider the intellectual processes with the measure of attention that they deserve, and the arrangement has one particular advantage. This is, that the reader may perhaps be helped to clearness in his study. Let us think of Psychology as the science of mind or, perhaps better, the science of human nature; and let us think of Logic as the science which concerns itself with the intellect and the intellectual processes. Logic is to be the subject of a succeeding course. But meanwhile, there remains a short space in which we may conclude the course on Psychology by a brief introduction to a question which has long interested the present writer.

The Future of the Race. We are all evolutionists nowadays; we "think in evolution"; and we sit no longer with averted gaze upon the unalterable past, but with our eyes upon the course that lies in front of our species and upon the distant goal. It has been admirably said that he who sets forth to discuss the theory of organic evolution but forgets its implications for the future is like a man who sets out to tell a good story but leaves out the point. Now, in preceding pages, we have referred to the development of mind, and it is not our intention to leave out the point.

The future evolution of man is of more interest to the psychologist than to the biologist. What is the meaning of this curious statement? It is that the future physical evolution of man *makes no great promises.* Biologists teach us that the animal race has ever been striving to become

erect, that man has gained the erect attitude, being not only man the erect, but, as Stevenson puts it, "man the erected," that his fore limbs are free for higher purposes than those of locomotion, and that the future course of his physical evolution will tend to consist rather in the disappearance of useless parts—such as toe-nails—than in the appearance of any new and important characters.

The Race is to the Wise. The first reason for this belief is, as we have already stated, that the goal of physical evolution—the attainment of the erect attitude—has been already reached; but there is another reason which is constantly forgotten in the popular notion of organic evolution—the most interesting, important, and misunderstood of all subjects about which anyone can write. The great agent of evolution is natural selection. Characters of body—and this is profoundly true of characters of mind—survive because they are of value in the struggle for existence. Without natural selection, choosing the best—as it usually does—and allowing the worst to die out, there can be no progress. One of the reasons why physical evolution makes few promises is that natural selection on this plane has been profoundly modified by the development of the human mind. The race is not now so much to the strong as to the wise; not so much to the lusty as to the self-controlled; not so much to muscle as to mind; not so much to brawn as to brain. Nowadays, if a man has a good head, he may survive and yield children who tend to inherit his advantage, even though he may be of small stature and a very poor match for a Hackenschmidt.

The Evolutionist Must Be an Optimist. Natural selection is now manifested most stringently in the sphere of mind. There is every reason to believe that the stringency of such selection will increase with the centuries. This necessarily means that every mental character which has *survival value* will be accentuated and multiplied. Clear perception, good memory, accurate association of ideas, vivid representation, strong inhibition, rapid and effective action when inhibition is removed, highly-developed but well-controlled emotions, keen but discerning sympathies—all these characters and many more will tend towards higher development. This is the belief of the evolutionist, who, as we have repeatedly maintained, must necessarily be an optimist.

If previous sections of this course have fulfilled their purpose, the reader will approach with a critical mind such an expression of faith as this; he will say, "I know you optimists: you have good digestions and sleep well, and you tinge your philosophy with the fortunate temperament which results from the smoothness of your internal processes."

But though much optimism is a matter of internal sensation—is, indeed, *organic optimism* as we have called it—this admission by no means excludes the possibility of an intellectual or rational optimism. Herbert Spencer and Charles Darwin, the greatest of evolutionists, were foremost as optimists, yet both of them suffered throughout practically the whole of their lives from nervous indigestion and insomnia.

The Future will be Greater than the Past. "What is possible for human nature here and there is possible for human nature at large," says Herbert Spencer. Sometimes, in our admiration for a Beethoven, a Goethe, a Newton, or a St. Francis we are apt to think that we shall not look upon his like again. But every one of such men is a demonstration of the possibilities of human nature, and is thus a certain proof that we *shall* look upon his like again—or better still, not his like, but his peer. The higher the plane upon which natural selection acts, the more rapid and certain will be the mental evolution of man. The higher the mental average of any society, the greater is its chance of producing the greatest men. This has been conclusively proved for us by Greece; it stands to reason; and it is in strict accordance with the laws of heredity discovered by Dr. Francis Galton.

There is one simple and obvious method by which mental evolution might proceed apace. If the father's knowledge were transmitted to his child, or if, even, the father's acquired facilities for attaining knowledge were transmitted to his child, if each generation stepped into at one pace, or rather possessed from the first, the sum of all the mental advance of all previous generations—then mental evolution would be a thing of lightning speed. The reader is, of course, aware that the possibility of the inheritance of acquirements of all kinds has been argued by biologists for decades past, and the verdict is an almost unqualified negative.

The Inheritance of Acquirements. Dr. Archdall Reid, who has been quoted elsewhere in this work, has shown that the physical continuance of the race would be impossible if the consequences of every injury, accident, and disease registered themselves in the next generation. From the point of view of the biologist and of the physician, it is a matter for congratulation that acquirements are not transmitted. Indeed, the race could not otherwise persist. But from the point of view of the psychologist, it is a matter of the utmost regret that acquirements are not transmissible. How pleasant for the reader's children if for them the SELF-EDUCATOR could be, so to speak, "taken as read," and they could proceed further, so much work having been done for them by their fathers, and its results transmitted to them by the laws of inheritance. But as everyone knows, this is not so. A man's wisdom dies with him; and the results of education directly concern the individual alone.

To this statement, of course, there is the qualification that, though a man's wisdom does die with him, strictly speaking, yet by means of speech and in infinitely greater degree by means of writing, it can be preserved. Many students have thought that the supreme advantage of man, as compared with the lower animals, is the fact that by such means the knowledge and wisdom of one generation are not lost, but persist.

Natural Selection in the Highest Sphere. In this limited sense it is true that we do indeed stand upon our parents' shoulders, and therefore can see further. The future of the race can never be the same as if Kant and Spencer had never lived; though these mighty ones left no children. But this indirect inheritance is a fundamentally different thing from the true inheritance of acquirements, and for its success it depends upon the inherent qualities of each generation. If some cause were to lead to the production of semi-human children, all that the kings of thought have accomplished would be lost in a generation; libraries and pictures and music scores would be burnt for fuel, and barbarism would have been re-established.

It follows, therefore—and this conclusion is of supreme importance—that the progress of humanity essentially depends, as also does even its retention of what it has already gained, upon the continued application of the law of natural selection in the highest sphere of all—the sphere of mind and character.

And here is the danger which many careful observers are coming to recognise. The future is the child of the present. The history of the human race is determined at any moment by the characters of those persons then living who become parents. The race will advance; stupidity and vice and brutality and ugliness of soul—these will disappear *according as the duty of continuing the race is performed by the best rather than the worst at any age and in any place.*

Society Breaks a Natural Law. Thus the birth-rate is a subject of the profoundest interest to the psychologist. Profoundly interested as he is in education, and convinced of its potency, he is yet equally convinced of the importance of *heredity* as well as environment or education, in matters of the mind. He realises that human nature is responsible for most of the evil of the world, and when he sees the birth-rate low among the thoughtful, the fine-minded, the sensitive, the sympathetic, and high amongst the brutal, the improvident, the criminal and the unself-controlled—he wonders what the upshot of it all will be. It seems to him that the beneficent law of natural selection, under which we have progressed thus far, is in danger of being set aside by society, consciously or unconsciously. Meanwhile, he looks with the utmost impatience upon bachelor bishops and others who lament the fall in the birth-rate without for a moment inquiring whether quality is not as important as quantity—and a millionfold more so.

The Science of Good Breeding. It is this question of the quality of our children—and pre-eminently, of course, in relation to the intellectual and emotional characters—that has engaged the attention of Dr. Francis Galton, the first student of heredity in psychology. The science or social creed which seeks to establish the encouragement of the parentage of the better and the discouragement of the parentage of the worst, this great student calls *eugenics*—which is literally good breeding.

The present writer, being a eugenist, is favoured with Dr. Galton's friendship, and has repeatedly written in favour of eugenics. The first appearance of this subject in the reviews is to be found in an article by the present writer, "The Essential Factor of Progress," in the "Monthly Review" for April, 1906. It is his hope that, having been privileged here to address such a magnificent audience as the SELF-EDUCATOR affords upon the science of mind, he may succeed in interesting not a few in that great practical doctrine to which, as it seems to him, all psychology must necessarily lead—the doctrine that mind is still in evolution and that it is our duty and privilege to accelerate as best we may this greatest of all processes. Then will our children indeed rise up and call us blessed.

The science of mind and character is the basis of all the human sciences. The more important of these are separately treated. The reader will follow naturally the rest of the subjects in this group. Immediately following upon this are PSYCHICAL RESEARCH and LOGIC, admirably contrasted as showing the variety of the studies to which Psychology leads. Thereafter the SELF-EDUCATOR deals with SOCIOLOGY—the science of man as *mankind*—and then with PHILOSOPHY and RELIGION, including the principles of morality.

VEHICLE UNDER-CARRIAGES

Railroad Under-carriages. Bogie Springs and Frames. Types of Road Vehicle Under-carriages. Beds. Wheels and Brakes

Group 29
TRANSIT
8
VEHICLE CONSTRUCTION
continued from page 3025

By H. J. BUTLER

HITHERTO we have dealt only with the body. Before the vehicle can be applied to the road an under-carriage or gear has to be made and fitted. Sleighs have merely runners attached to separate the bottom from the frozen road, while sling vans are an instance where the body is transferred from one under-carriage to another.

Although there are still plenty of four and six-wheeled railway vehicles in the United Kingdom, the bogie type will soon be as prevalent here as it is in the United States. Having reached the limit of width in our railway rolling stock without increasing the loading gauge, it is the natural tendency to design long vehicles. These demand special under-carriages capable of negotiating safely and easily the curves of the permanent way.

Bogies. The car truck or bogie may be considered as a little wheeled vehicle in itself, through the centre of which runs the pivot or king bolt on which the superimposed body turns. The bogie is also designed with the view of giving increased riding comfort by the arrangement of its springs. Bogies may be four or six-wheeled.

The shocks from the rails and points are transmitted to the wheels and then to the springs immediately supported over, or in some types connected with, the journals. These springs are attached to the bogie frame, on which is mounted a second series of springs. By this means the vibration is well absorbed before it reaches the central turning pin of the bogies, thereby giving a degree of comfort impossible with the directly hung four and six wheeled carriage. The bogie carriage is also a larger, and consequently heavier, vehicle, which means smoother riding.

A similar scheme of isolation of the body from the inequalities of the road is seen in the C and under-spring perch under-carriage of a victoria or brougham, and in the mail under-carriage of a phaeton or drag.

Bogie Springs. In rail and tramway work both helical and laminated springs are used. The helical spring is a spiral or coil spring, which in heavy freight car bogies runs up to 1¼ in. coil, the internal space inside being about 3 in. Laminated springs, or those made up of leaves or plates, are elliptic in American practices, while here the side or half elliptic is mostly used at present in bogies.

Regarding the distribution of these types, generally speaking the car trucks in the States take the first shock in the helical side springs and transmit them to the elliptical bolster springs. These bolster springs may be double, triple, or any number in side combination up to six. The English practice is to reverse the placing of the two varieties, and we are familiar with the long side body springs seen under our bogie coaches.

The drawback in laminated springs is the friction set up between the plates. This retards their action to an extent. On the other hand, the helical variety are often too responsive, and mechanisms known as *dampeners* are adopted as reducing agents.

Bogie Frames. The use of oak and ash in the construction of bogie frames has been upheld on the argument that this material is a better absorbent of vibration than metal. In American car trucks these woods are largely used, the fact that there is plenty of the timber at hand being no doubt a stimulating influence. But timber, especially in these large pieces, is liable to be unseasoned and faulty; also, steel is much cheaper than formerly, and makes a far stronger and more reliable frame. Bogies may be of wood strengthened with plates, of wood and steel, or of steel only. An English type of the second variety will now be described.

An English Bogie Frame. The frame work is of mild steel, the sides (*solebars*) and ends (*headstocks*) both being angular in section. In the centre some 16 in. apart and parallel with the headstocks run the two channel steel cross-bearers. This skeleton is strengthened with four diagonal pieces of angle steel riveted on top, two connecting each crossbearer and headstock.

These cross-bearers perform the important function of carrying the ash spring beam and the superimposed helical bolster springs, above which is the oak bolster itself, with its 2½ in. pin. On this pin the body turns, so we see that the cross-bearers perform a vital function. Perhaps the term *body springs* suggests their importance better than bolster springs. Both the spring beam and bolster are plated on the side. The vertical movement imparted to the bolster by the springs underneath naturally causes friction between the outside of the bolster and the inner surface of the cross-bearers. Wearing plates are therefore fitted. The helical springs are retained in a proper working position by cast-iron blocks bolted above to the bolster and below to the spring beam. Directly to the solebars are swung the side springs, which are attached in the centre over the axle boxes.

It will be noticed that these springs are outside the wheels, an opposite practice to the method usually adopted in road vehicles. Although some London omnibuses were so fitted, their building has now been discontinued.

Into the channel of the cross-bearers is fitted a cast-iron packing block at each end by the solebar, the whole being drilled to take mild steel U-shaped suspension bolts. From these bolts swing the fork hangers, which drop close to the outer edge of the spring beam. Then from the lower end of each pair of hangers are attached the spring beam castings, which pass underneath the beam and are checked in ⅜ in. The fork hangers do not hang vertically, but are inclined inwards at the top, so minimising oscillation.

The two sets of three helical springs are arranged in the form of a triangle, the apex of which points towards the inside, one spring being ⅞ in. shorter than its fellows, a combination which prevents to a great degree the rolling of the vehicle. Sometimes a helical spring is placed inside a larger one to economise room, but it has the distinct disadvantage of causing a broken spring to remain unnoticed. On the top of the bolster we have at each end the cast-iron side-bearers for the body, and in the centre the pivot with its plate, the bolts which fix it being carried through to retain a plate on the underside of the timber. From 6½ in. at the sides, the bolster is strengthened to 8 in. in the centre.

Apart from all this, provision has to be made for carrying the brake, and when the position of any members can be designed to take the fittings for the brake without the use of special iron work, the plan is adopted.

An American Bogie Frame. A Pullman six-wheeled passenger car truck is made up of two American white oak sides (*wheel pieces*), plated with an inside and outside wheel piece plate. The wheel pieces are joined by the *end pieces*, which we call *headstocks*. In the centre, parallel with the end pieces, we have two wooden outside transoms.

To the top of the spring beams are bolted the centre bearing arch and inverted arch bars. These two bars are together at the transoms, but one arch bar rises while the other falls, so that at the centre they are capable of embracing the centre brace block, which carries the truck centre plate.

From the outside and middle transoms fall the swing fork hangers, at the lower extremity of which is attached the spring plank. Between the spring plank and the spring beam are the four double elliptical bolster springs.

The side helical springs, or equalising springs, are retained in position by the equalising bar, which runs from the tops of the axle boxes, dipping down between each, the springs resting in the middle of each dip. The tops of the equaliser springs are retained under the wheel pieces.

Difference Between English and American Bogies. The chief difference between the two trucks is that the four-wheeled English one has the bolster springs and body bearings in the centre between the wheels, in a mild steel frame strengthened with diagonals, while the six-wheeled Pullman, the bearings being also in the centre, has the bolster springs between the centre and side axles mounted in a wooden plated frame strengthened by longitudinals, and the side body bearings are outside the frame proper while inside in the British design. There are numerous other types of bogies or trucks, but their system and arrangement have the same underlying principles.

Road Vehicle Under-carriages. The bogie of a railway coach has no great amount of *locking* or lateral motion when rounding a curve, but a brougham or victoria is often called upon to turn completely round in a street of medium width. This motion is provided for in the presence of the wheel plate (or American *fifth wheel*). The body has to be designed to allow of the free passage of the wheel while turning. In some cases only a partial lock is provided.

C and Under-spring Perch Suspension. The perch under-carriage [40] is the better and older form of suspension for road vehicles, but is now comparatively little used. The body is hung at the back and front by four braces, passing round C springs, to which they are attached and regulated by winding jacks. These springs are fixed to the front and hind under-carriages. The two under-carriages are held together by the perch, thus giving more direct draught and preventing the tops of the C springs from being pulled in. Naturally a body hung at each corner on a leather strap tends to sway uncomfortably when on a rough road. To counteract this swaying, check braces are attached to the body from the belly of the perch. Broughams, landaus, victorias, sociables, double victorias, lady's driving phaetons, and all carriages used on special occasions, such as dress coaches, chariots, and landaus [40] are fitted with this suspension. The details of construction, as shown in **40**, are as follow:

1. Salisbury boot	9. Check brace
2. Body loop	10 & 11. Under-spring
3. Close futchell	12. Platform
4. Dumb	13. Jack of C spring
5. Front C spring	14. Band of C spring
6. Hind C spring	15. Shackle of C spring
7. Standard	16. Scroll of C spring
8. Wood perch	17. Platform block.

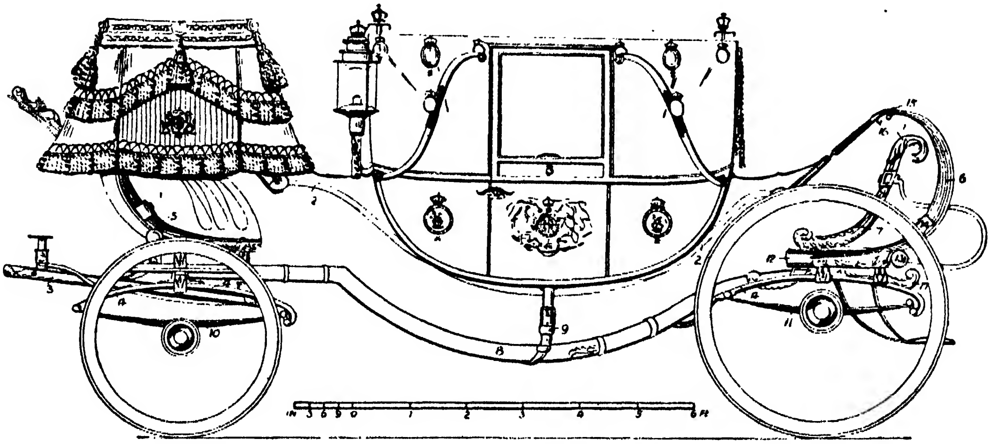
In a perch under-carriage the front wheels in turning can travel only as far as the centre of the body, less half the thickness of the perch. In some cases the perch has been cranked upwards to allow of a free passage, but this entails heavier material and costlier working, and is rarely seen. In the ordinary perch under-carriage a locking stop is provided on the wheel plate to prevent the tyre from striking the side of the perch.

The Perch Under-carriage. The several members of a perch under-carriage are shown in **40**. Attached to the top of the wheel plate we find the top bed or transom, the middle of which is placed immediately above the turning centre, and therefore usually receives the perch bolt, called, in America, the *king bolt* or *centre pin*. The transom is usually plated on top, the greatest thickness being in the centre, so as to accommodate the head of the perch bolt. Also, on the top of the wheel plate and taking the hind bearing, the horn bar is found. The transom and horn bar receive on their extremities the two front

C springs, to which they are bolted. Flapped on the horn bar and taken through the transom runs the front of the porch, which is smaller at the front than at the back of the wheel plate. A pedestal makes up the thickness in front, where it is bolted to the wheel plate. Often the perch stops at the transom, and a stay is provided from the top of the perch bolt to the front of the wheel plate. Between the perch and spring bearings two nunters are framed through. Immediately under the wheel plate is found, centrally and carrying the lower half of the perch bolt, the axle or bottom bed. It is usually strengthened underneath with a bottom bed plate, thicknessed in a similar manner to the transom plate and running up to under the spring carriage beds by being flapped above them. In a closer coupled carriage one may often find the two hind beds equidistant from the axle; when one of the beds is found immediately over the axle it is not unusual to call it the *hind axle bed.*

Nunters are also framed through these beds as they are through the transom and horn bar in the fore-carriage. The hind C springs are similarly fixed, likewise the dumb and under-spring. An important piece of iron work, the hind cross stay, is provided, running from the front of the hind dumbs to the perch.

The Mail Under-carriage. Another type of perch carriage is the mail under-carriage [41], used under four-in-hands, brakes, and phaetons. The details of construction shown in the illustration are as follow:



40. SIDE VIEW OF A DRESS LANDAU
Showing under-carriage, having a C and under-spring suspension combined with a wooden perch

dumbs. Through the axle bed is framed the close futchells. Immediately under the wheel plate, at the pedestal, we find the front felloe piece, and at the back the hind felloe piece. They are fixed to the futchells below. At the extremities of the bottom bed, a clip is placed over the dub ends and bolted together on to the top of the dumb with the bottom bed plate, the last mentioned being underneath the dumbs.

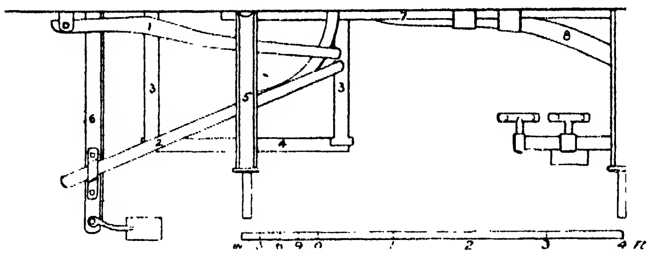
The dumbs are solid, imparting no spring motion. They serve to connect the ends of the under-spring, a shackle being provided at the rear to allow of lengthening, under the varying load. A stay usually runs from the ends of the futchells to the top of the dumbs, and is there bolted. On the futchell, sometimes *under* it in the case of a curved pattern, is fixed the splinter bar, to which the horses are attached. A split stay is generally provided, running from the end of the splinter bar to the top of the dumb. In heavy dress work, two stays will also be found connecting the ends of the transom and horn bar. The under-springs are clipped to the axle flaps. Thus we complete a brief summary of the fore-carriage.

Following the perch, as it leaves the wheel plate, we find it following, to a great extent, the bottom comformation of the body. The perch, when iron, is connected to the two hind

1. Close futchell
2. Outrigger futchell
3. Cross spring
4. Side spring
5. Bedded axle
6. Splinter bar
7. Wood perch (straight)
8. Wing of perch
9. Elbow spring
10. Hind bar
11. Cross spring

The great difference between this mode of suspension and the C and under-spring types lies in the fact that the body is attached directly to the springs. In a drag, these springs, both back and front, are platform springs, a combination of two side and two cross springs. The cross springs are attached to the body, and the side springs to the cross springs by shackles. The latter are clipped to flaps, forged in the solid with the bed plate. In addition to the close futchells, outside or outrigger futchells are provided, which are clipped to the splinter bar in front and to the axle bed at the rear. The axles are wood-bedded, thus forming a bottom bed, while the axle takes the place of the plate. Through the bed, which rests on a half wheel plate, the perch is framed; its belly follows the downward sweep of the body rockers and rises upwards, aided in its duty of retaining the hind carriage by two side perch-wings, all of which are framed through the hind bedded axle. The

wooden perch is always plated, and the wings are sometimes plated. In a mail phaeton we have a similar fore-carriage, but a straight perch, and the hind suspension consists of an elbow and cross spring suspended on a gallows iron, which is flapped on a hind bar beyond the hind axle, into which the perch and wings are framed.



41. HALF PLAN OF A PERCH MAIL UNDER-CARRIAGE SUITABLE FOR A PHAETON

American Perch Carriages. In a mail under-carriage the shackles would not be capable of performing their function without a perch. In American buggies, however, we see types of supension in which, although the connecting member is not absolutely necessary, its presence is most certainly an important factor in keeping the front and hind gears rigid and parallel, and at the same time the pull of the animal is first transmitted to the two axles, which is justly considered an agent in reducing the draught. Elliptic springs may be placed either longitudinally or transversely. Several types of side and cross springs are also mounted in various combinations. The great characteristic of this class of work is the elimination of material to the barest margin of safety. The cost of production is small. The style is suited to roads that are such in name only, yielding to the inequalities of the ground where a stubborn and stronger make would break. Besides, if it does collapse, a whole vehicle can be supplied almost as cheaply as the repair of a heavier type of under-carriage.

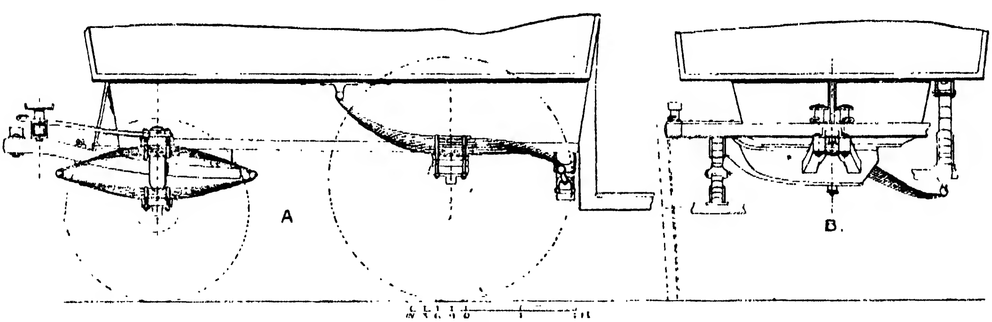
The Usual Type of Suspension. No doubt the most familar type to English eyes is the under-carriage without a perch [42–47]. Broughams, phaetons, and other four-wheeled carriages are hung in this manner in a large majority of cases. Excluding American types, Army waggons, timber trolleys, and the like, all four-wheel vans are hung without a perch.

In underworks of this type one usually finds two elliptic springs in the fore-carriage, and also in the hind suspension. The latter part, however, is sometimes fitted with two ¾ in. elliptic springs shackled to a cross spring. Where a heavy load is supported immediately over the hind axle, as in an omnibus [42] or waggonette, we see the use of a side spring justified, sometimes in conjunction with a cross spring. Light vans are sometimes hung in the same way as private carriages.

The Elliptic Spring Under-carriage. The general arrangement of the members in an elliptic spring carriage [43–47] differ little from the perch variety. The front of the perch is replaced by the framing piece, which, in front of the transom, is termed the tongueing piece. Both the transom and horn bar are bolted above to the bottom boot-framing.

In place of the front and hind stay to the dumbs, we have respectively the wheel iron and its back stay This, however, is sometimes fitted to the perch carriage. In both types the use of one horse demands open futchells, with an adjustable splinter bar [43], in case the owner should at any time wish to drive a pair.

The hind carriage consists of the two pump-handles, generally of iron, or sometimes wood-cased; these are attached to the body at one end and the hind springs at the other. A bar—a hind carriage-bar when the pump handles are placed on it, and a pump-handle bar when framed into wood-cased pump-handles—connects the two springs transversely, although some builders consider the vehicle safe enough without it. A detailed list of the parts of an elliptic spring under-carriage are as follows:



42. GARDEN SEAT OMNIBUS UNDER-CARRIAGE
A. Side View B. Front View with part removed to show hind suspension

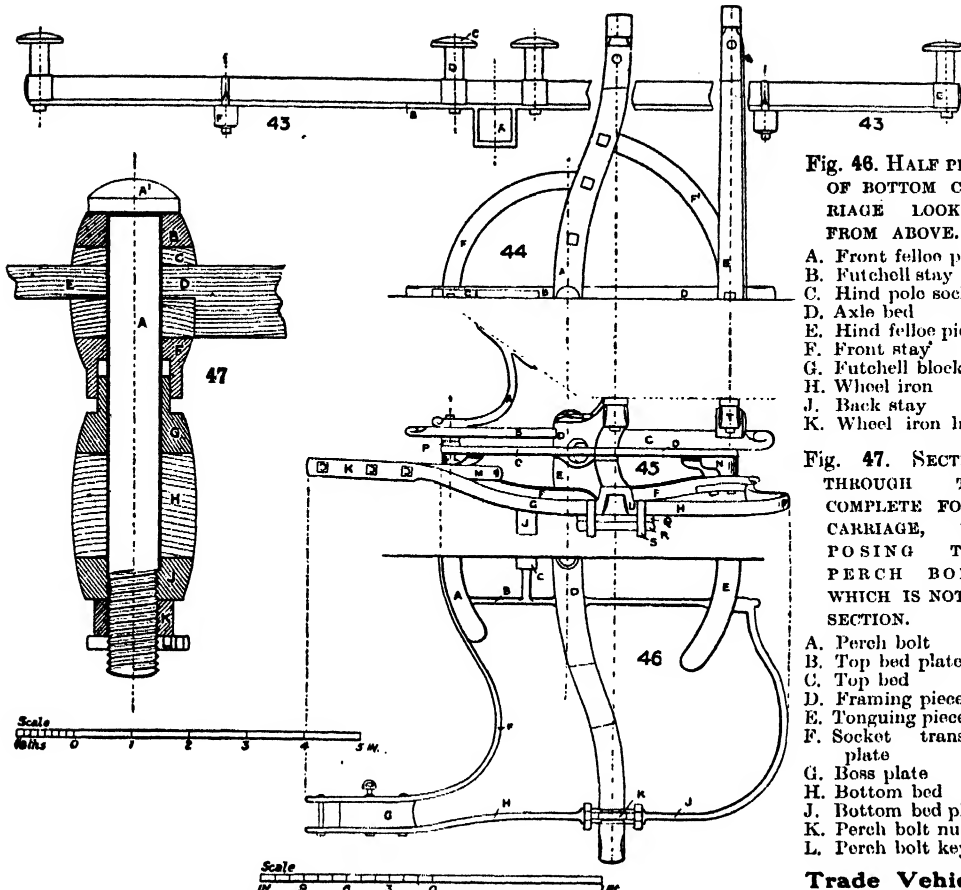


Fig. 46. HALF PLAN OF BOTTOM CARRIAGE LOOKING FROM ABOVE.

A. Front felloe piece
B. Futchell stay
C. Hind pole socket
D. Axle bed
E. Hind felloe piece
F. Front stay
G. Futchell block
H. Wheel iron
J. Back stay
K. Wheel iron head

Fig. 47. SECTION THROUGH THE COMPLETE FORE-CARRIAGE, EXPOSING THE PERCH BOLT, WHICH IS NOT IN SECTION.

A. Perch bolt
B. Top bed plate
C. Top bed
D. Framing piece
E. Tonguing piece
F. Socket transom plate
G. Boss plate
H. Bottom bed
J. Bottom bed plate
K. Perch bolt nut
L. Perch bolt key

43–47. ELLIPTIC SPRING UNDER-CARRIAGE
For details see text

Fig. 43. FRONT VIEW OF A SPLINTER BAR SUITABLE FOR FIXING TO AN OPEN FUTCHELL CARRIAGE.

A. Front pole socket
B. Bottom plate to bar
C. Roller bolt cap
D. Roller bolt ferrule
E. Splinter bar socket
F. Block for insertion into futchell jaw

Fig. 44. HALF PLAN OF THE TOP CARRIAGE OF AN ELLIPTIC SPRING FORE-CARRIAGE LOOKING FROM ABOVE.

A. Compassed top bed or transom
B. Tonguing piece
C. Footboard stay
D. Framing piece
E. Horn bar
F-F′. Wheel plate

Fig. 45. SIDE VIEW OF AN ELLIPTIC SPRING FORE-CARRIAGE.

A. Footboard stay
B. Tonguing piece
C. Framing piece
D. Top bed or transom
E. Bottom or axle bed
F. Futchell stay
G. Wheel iron
H. Back stay to wheel iron
J. Hind pole socket
K. Futchell jaw
L. Front felloe piece
M. Circular shaft bar or front stay
N. Hind felloe piece
O. Wheel plate
P. Pedestal
Q. Flap of the bottom bed plate
R. Spring block
S. Spring clip
T. Horn bar
U. Wheel iron head

Trade Vehicle Under-carriages

A four-wheeled tradesman's vehicle, although, in its lighter varieties it follows closely the practice adopted in private work, has many types of suspension special to its class. The most common is the square-framed under-carriage in front, made up longitudinally of four guides, with a transverse front and hind bar.

Attached to this frame we have the wooden sweep-pieces and bottom bolster. To the bottom framing of the van body are bolted the top bolster, and the front and hind attachments to the wheel-plate, which are of many types.

Sometimes pedestals are used. Often a bar or shaped block does the duty. Pedestals are also found in the bottom carriage. The wheel plate is necessarily of a larger diameter and thicker than in private carriages. Under the frame is clipped elliptic springs, but far more frequently we find on the under-side the flaps of the bridge or globe scrolls from which hang the side spring. Likewise, we find side springs predominating in the hind carriage, the scrolls in this case being hung from the summers specially placed to take them. Under the frame over the axle we find another bar, which in heavy vans loaded to the front takes the front check

spring. A hind bar is similarly fitted to the body to take the hind cheek spring when used.

Two-wheeled Suspension. Vehicles with two wheels have similar means of suspension, in both trade and private work. The greatest difficulty is the proper balancing of the body. The most common method of hanging is by two side springs, with or without a hind cross-spring. We have also two elliptic springs, used in some cases under carts of various patterns and governess cars. Gigs have special types of hanging devoted to them, as mentioned under the varieties of vehicles. Some two-wheel carts are fitted with a pole, the two horses being attached to a yoke suspended in front of them from their collars, as in a cape cart. In the old-fashioned curricle the yoke rests on the horses' backs.

Truck Under-carriages. Among trucks the Slingsby's patent under-carriage deserves mention. It consists of three axles, the central one having attached to it two wheels in the usual manner, while the back and front axles have each one wheel, which is free to slide and revolve along the axle between the bearings. Also, it is so arranged that the two side wheels rest on the floor with only one of the sliding wheels, therefore only three wheels touch the floor at a time. The suspension of perambulators and similar small vehicles is shown in **48** and **49**.

Under-carriage Beds. Beds or bolsters are usually straight in van and railway work, but the carriage maker in the coachbuilder's shop often compasses them forward in the centre to effect a more compact vehicle. A medium distance is 3½ in. In this way the axle, and consequently the wheel centres, are 3½ in. behind the perch bolt and turning centres. A bed so formed, owing to the strains and shocks it has to sustain, must under no circumstances be made of bent timber, as is seen in some cheap Continental vehicles, but must be sawn from best ash, with the grain running as much as possible in the direction of the piece in question.

Boss and Socket Transom Plates. Under the transom bed is fixed the socket transom-plate, while on the top of the axle bed is secured the boss plate. The fitting together of these two pieces of ironwork forms a collar that works round the perch bolt [47], and in the unlikely event of a broken perch bolt the arrangement adds to the safety of the vehicle.

Wheels. When primitive man wished to move an object along the ground he found that the tree trunks lying around when placed underneath considerably reduced the friction and, therefore, the amount of energy required for removing the article. From the roller the wheel was evolved, and it is very easy to imagine that the first wheels were simply discs. We associate the first wheels with the chariots of old. On the invention of the wheel the whole trade of the building of all types of vehicles has sprung up, and to detailed improvement we owe the presence of cycles and motor-cars of all descriptions.

Wheels in road vehicles transfer the friction set up between the outside of the tyre and the road surface to a generally highly lubricated and specially hardened axle arm and encasing box. It will be seen that the larger the circumference of the wheel, the easier it will surmount obstacles and the fewer revolutions it will make in travelling a given distance, therefore setting up less attrition. Likewise, the smaller the relative size of the axle arm, the less the frictional surface.

However, in most vehicles a large wheel is inconvenient for many practical reasons, and we must not diminish the diameter of the axle arm beyond a certain point in proportion to the load, otherwise the safety of the vehicle and its contents will be endangered.

Railway Wheels. In railway work the wheels run on a metal track, and have, except for the breaks between the rail lengths and at the points and crossings, no obstacles to surmount as a road vehicle has. The presence of a track 4 ft. 8½ in. wide has necessitated building over the wheels, so that we see the wheel diameter reduced in many cases to 33 in.

Generally, a steel tyre is bolted to a centre which may be composed of compressed paper, cast-iron (either of disc or spoked form), or of wood. Various methods of fastening the tyre have been invented. Also the whole wheel may be of chilled cast-iron, which forms a type in favour for tramcars.

Wheels of Road Vehicles. The wheels of road vehicles consist of an oak stock for heavy work, and elm for light work, mortised to receive the tenons of spokes—in this country of oak, and in America of hickory. The outer ends of the spokes are tanged in pairs into an ash felloe, or into a hickory rim bent by steam.

The whole is protected and strengthened by a steel or iron tyre shrunk on either by natural contraction after heating, or by cold hydraulic pressure.

Stocks. After proper seasoning, during which the centre has already been bored out, the sapwood is removed, and the stock turned to the pattern required. After hooping it is ready for mortising. The centre of the spoke must be on the centre of the axle box.

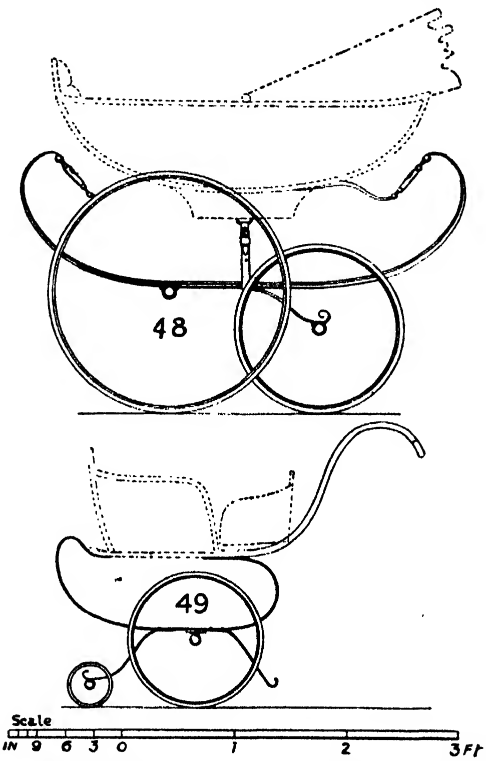
Spokes. The number of machine-made spokes greatly exceeds those made by hand. Many will affirm that a hand-made spoke is stronger. Naturally, a machine will get a spoke out of a piece of timber whether it is fitted for it or not, much depending on the forethought and capabilities of the man in charge. The hand-made spoke is cleft from pieces of oak a little larger than the finished size. Placing the sapwood to the front, they are planed up true, and the face squared, care being taken that the foot is in an exact line with the body of the spoke. After the spokes are fitted to the stock, the wheel or *speech*, as it is called, is now ready to receive the felloes.

Felloes and Tyres. The felloes are fitted so that, although meeting on the inside, they are open about ¼ in. on the outside. Also, they are got out to a shape that is a little higher than the given diameter of the wheel. Generally, the

proportions are 3 ft. $\frac{11}{16}$ in. for a wheel given as 3 ft., and so on, allowing about $\frac{9}{16}$ in. for every foot of wheel diameter.

In fitting the spoke into the felloe the tangues are split and wedged with a piece of oak, usually a spoke cutting. Dowels are also made of the same material. The tyre is shut up a little shorter than the circumference of the felloes, the actual measurement depending on the nature of the material used, its thickness, and the type of wheel about to be shod.

Dished Wheels. The most casual observer will notice that wooden wheels are dished—that is, the distance over the top of the wheel is greater than a corresponding measurement taken on the road. It is said that a wheel so formed looks better, is stronger, but what is more important, causes the wheel to wear against the axle collar rather than the outside collet or nut, a state of affairs which is obviously safer. The practice of lessening the dish of wheels in private carriages is to be commended, for its exaggeration certainly detracts from the beauty of an otherwise well-designed carriage. Artillery wheels have the foot of the spokes cut so as to form a perfect arch resting round the axle box, completely filling the space between the latter and the bolts of the hub flange. We should include castors with wheels, as they are adapted to many forms of trucks.



48–49. SUSPENSION OF BABY CARRIAGES

Brakes. The first idea of a brake was to retard the motion of a vehicle when descending an incline, and in road conveyances this is its chief use. But on the railway the powerful types used are to bring the train to a standstill not only at the station platform, but also when a signal may be at danger. Road-vehicle brakes are also fitted, so that progress may be checked as the exigencies of the traffic demand, and any case of emergency that may arise from pedestrians or otherwise.

The chief types of brakes used on railways are the vacuum and the Westinghouse. It must be at once admitted that a certain amount of controversy exists as to which is the better. Both are described, and the reader may judge upon which side superior merit lies.

The Vacuum Brake. In the vacuum automatic brake the power is applied by admission of air to the apparatus, while it is released by the creation of a vacuum To quote from the company's handbook, "The brake can be applied by the guard, and is self-acting in the case of an accidental parting of the train, or any damage happening to the brake itself. It is instantaneous in its action, and can be regulated to a nicety for easy stops, or to control the train on an incline."

The Westinghouse. The Westinghouse brake is applied by the application of compressed air, and released by the reducing of that pressure, and, as in the vacuum brake, an accidental fracture applies the brake blocks to the tyres.

The difference between the two types lies in the fact that the vacuum depends on the comparative absence of air (an absolute vacuum being impossible) for releasing the brakes, while the largely-used American type requires merely a reduction in the air pressure to effect the same object.

Working of the Vacuum. In the Vacuum brake the brake blocks are connected by levers which are moved by a piston working in a cylinder. The pressure is applied by admitting air into the bottom of the cylinder below the piston, which in rising, applies the blocks to the tyres.

The brake is released by exhausting the air below the piston by the admission of steam to a small ejector under the engine-driver's control. The braking power may be destroyed more promptly by using a larger ejector, which is also fitted in the engine. These two ejectors are known together as the combination ejector, the smaller being placed inside the other. The former is worked continuously to maintain the vacuum necessary while the train is running.

Working of Westinghouse Brake. In the Westinghouse brake a double-acting air pump is necessary on the engine. It consists of a steam cylinder on top, and an air cylinder below. By means of valves and pistons the steam pressure drawn from the locomotive stores up compressed air in a main reservoir situated under the footplate, which is connected to the air cylinder by a delivery pipe. From the top of the reservoir runs another pipe, to which is attached the driver's brake valve, which is also connected with the main brake pipe running the whole length of the train. This pipe is capable

of being detached at each end of each carriage or car, and control is also placed in the guard's van.

In the latest types of Westinghouse pumps, a steam pressure of 140 lb. will fill the main reservoir of 10 cubic ft. with air compressed to 95 lb. per square inch in 100 seconds. The connections between the carriages consist of flexible rubber hose attached by couplings. When not in use a dummy coupler may be attached to the free end of the hose to exclude dust and grit.

The actual braking apparatus consists of a brake cylinder and piston as in the vacuum type, but an auxiliary reservoir supplied with air from the main reservoir is also part of each vehicle equipment. A triple valve admits air from the auxiliary reservoir to the brake cylinder when the pressure in the main or train pipe is reduced by the driver allowing it to escape at his brake valve, and when the brake is released by increasing the pressure the air escapes from the cylinder into the air, and the train pipe again fills the auxiliary cylinder. The piston rods, as in the vacuum brake, are connected with the brake blocks, and both brakes may be applied gradually or suddenly.

Relative Use of Brakes. The vacuum brake does more mileage and records fewer faults per mile than the Westinghouse in the United Kingdom. Both the Great Western and London and North-Western are fitted with the vacuum, while the London, Brighton, and South Coast and the South-Eastern and Chatham use the other. Some railways have part of their stock fitted to take both systems. The Westinghouse is an older invention, and finds almost universal favour in the land of its birth—the United States.

Road Vehicle Brakes. No doubt the first brake application was by tying up the wheel; after that came the skid under the wheel, and from then friction has been set up in various forms between the tyre and a block. Sometimes the rim or hub is utilised for this purpose.

The Bowden Brake. Among modern brakes the Bowden wire principle as applied to cycles and lately to carriages, is simple, neat, and powerful. It consists of an inner strand of inextensible wire, over this being a tube of closely-coiled wire incapable of compression lengthwise, while outside both is a protecting jacket to prevent mud or other matter from affecting the tube coil. The action consists of the pull of one wire and the resistance of the other, and the power can be transmitted up and down any path curved or straight between the brake handle and the point of application. In a gentleman's carriage the attachment of a wire cable instead of the usual ugly and cumbersome levers and connecting rods is a distinct factor in enhancing the appearance of the vehicle. Likewise, the cyclist finds he has a featherweight brake.

A brake applied to the rear wheels of cycles does not interfere with the steering, and when applied to the rim, saves the tyre. For many reasons a hard steel wheel rim is a better point of application than is the surface of a tubular indiarubber tyre.

Band Brakes. The motor is an instance where band brakes are largely adopted. They are fitted to the countershaft and the hind driving wheels, in the latter instance being often water-cooled. The power is applied by hand levers or foot pedals attached to rods and cables. As in cycles, the pneumatic tyre precludes any direct application to the tyre. Solid rubber and iron tyres, however, allow of the use of spoon and block brakes and less strain is thrown on the wheel.

The application of the countershaft brake usually takes out the clutch, thus disconnecting the engine. Should the brake fail on an incline, a sprag is fitted to drop down and check the car from running backwards, or a ratchet is made to engage in a ratchet-wheel on the countershaft.

Lever Brakes. The remaining brakes are those that depend on the power transmitted from a lever. Sometimes we have a single hand lever connected direct to the rolling bar which actuates the brake arms, or we may have an intermediate connecting rod. The power may also be applied by a foot treadle or by a hand wheel. The connecting rod is often swept to conform to the shape of the vehicle. A brake lever rack is for maintaining the pressure when applied. The lever may simply be pushed sideways out of its resting place in the rack teeth, or be released by a trigger, a practice favoured in motor engineering. A treadle may give a vertical pull or a horizontal pull or push, also a screw brake may work vertically or horizontally. Brake blocks and pans are of many designs. In a perch under-carriage the brake work must be fixed to it and not to the body. Here the Worger-Bowden brake has a decided advantage over the older types. Van brakes are usually powerful types of the lever brakes mentioned. Tramcars use magnetic brakes as well as other varieties.

Continued

THE NOVEL & ITS CREATORS

Richardson, Fielding, Smollett. Notable Novels and Women Novelists before Scott. A Further Study in English Prose Fiction

Continued from page 2863

By J. A. HAMMERTON

Samuel Richardson. The "literature of the drawing-room," which Lyly began, was humanised by SAMUEL RICHARDSON (b. 1689; d. 1761), who may be called the father of the domestic novel. As a lad he was the confidant of the young women in the neighbourhood of his home in Derbyshire, the whereabouts of which, for some obscure reason, he successfully concealed. He read and wrote their love-letters for them, which accounts in some measure for his extraordinary success as a writer, chiefly for women, in the later years of his life. At the age of two score and ten, when he was a printer in Salisbury Court, Fleet Street, and possibly, it is suggested, after he had read Marivaux's "Vie de Marianne," as translated and continued by Mme. Riccoboni (1736), Richardson—who knew no language but English—was induced by two bookseller friends to take up the task of writing a book of "Familiar Letters on the Useful Concerns in Common Life." He was doubtless engaged in this work when he became acquainted with the story which inspired his first novel, "Pamela; or Virtue Rewarded" (1740), although the latter was published several months before the "Familiar Letters." "Clarissa Harlowe" followed, in 1748; and "Sir Charles Grandison," in 1753. These three works form, as Professor Raleigh has remarked, a kind of trilogy, dealing respectively with humble, middle-class, and high life. Professor Raleigh has a capital chapter on Richardson; but the student should not omit to read Mr. Austin Dobson's monograph in the "English Men of Letters" series. One of the most remarkable things in connection with Richardson's work is the deep and abiding interest it has aroused in France.

Richardson's Characteristics. His adoption of the epistolary style was at once condemned by Fielding; but, though Fielding's protest was well grounded, the method had its advantages, and is sometimes adopted even now. Perhaps the greatest obstacle in the way of a popular appreciation of Richardson to-day is his prolixity; and another drawback is his passion for moralising. Still, as Mr. Dobson says, he "must always find readers with the students of literature. He was the pioneer of a new movement; the first certificated practitioner of sentiment; the English Columbus of the analytical novel of ordinary life. Before him, no one had essayed in this field to describe the birth and growth of a new impression, to show the ebb and flow of emotion in a mind distraught, to follow the progress of a passion, to dive so deeply into the human heart as to leave—in Scott's expressive words—'neither head, bay, nor inlet behind him until he had traced its soundings, and laid it down in his chart, with all its minute sinuosities, its depths and shallows.' Added to this there was something in his nervous, high-strung constitution—a feminine streak, as it were—which made him an unrivalled anatomist of female character."

Must We Read Richardson? To be perfectly frank we find ourselves unable to urge Richardson upon the general reader. The abnormal length of his novels, their sluggish movement, their lack of real dramatic action, their mawkish sentimentality—these are defects enough to encourage the dust upon them. Let anyone who has not yet attempted to follow the adventures of "Pamela," one of the least attractive females in the whole realm of fiction, or the "impossible" story of "Clarissa Harlowe," or the soporific and interminable history of "Sir Charles Grandison"—let anyone do so, the attempt may at least be made—and none will blame him if he concludes that Richardson is not his favourite romancer. For the student of eighteenth century life, however, the novels of Richardson contain much that is invaluable, as the little printer could certainly observe and portray character as he saw it. Indeed, the fact that he could have won with these three books such immense popularity as he enjoyed in his own day is of itself a valuable index to the mind of his age. We live in brisker times, and are happily less sentimental in the twentieth century. Compare modern character as a whole with that illustrated by Richardson, and it will be found that the change is all for the better. Mr. Andrew Lang could not read "Rob Roy" until he was forty. The present writer read "Pamela" when he was nearer fourteen—chiefly because his mother prohibited the book—and it would have been no deplorable thing had he postponed its reading until after forty, or even until four score years! This touch of purely personal opinion at the present point is thought desirable, since it is unwise to dogmatise over Richardson, and the taste of each reader must decide the matter for himself.

Henry Fielding. Richardson's relations to his great contemporaries are thus happily and humorously indicated by Mr. Andrew Lang: "Richardson was a woman's novelist, as Fielding was a man's. I sometimes think of Dr. Johnson's saying, 'Claret for boys, port for men,' and smiling, 'brandy for heroes.' So one might fancy him saying, 'Richardson for women, Fielding for men, Smollett for ruffians,' though some of the latter writer's rough customers were heroes, too."

Two years after "Pamela" was issued there appeared "The History of the Adventures of

Joseph Andrews and his Friend Abraham Adams, Written in Imitation of the Manner of Cervantes, Author of 'Don Quixote.'" In this work HENRY FIELDING (b. 1707; d. 1754), barrister, journalist, and playwright, essayed a satire and achieved a masterpiece, just as Cervantes himself had done. The Parson Adams of the story takes rank in the gallery of the heroes of English fiction with Goldsmith's Dr. Primrose — just as Sophie Western sits with the daughter of the Vicar of Wakefield. "The History of Tom Jones, a Foundling," appeared in 1749; "Amelia" in 1751. The "History of the Late Mr. Jonathan Wild the Great," was published among his "Miscellanies," in 1743. Thackeray, whose outlook on the world was similar to Fielding's, has said of him: "He may have low tastes, but not a mean mind; he admires with all his heart good and virtuous men, stoops to no flattery, bears no rancour, disdains all disloyal arts, does his public duty uprightly, is fondly loved by his family, and dies at his work." Thackeray's appreciation is a good antidote to much of the depreciatory criticism that has been passed upon Fielding the man.

The Place of Fielding. As a literary artist, if not as a reader of the human heart, Fielding has a place above Richardson, and Sir Walter Scott styled him the "Father of the English Novel." He is a humorist, which Richardson is not. His knowledge of life is wide, his sympathies are catholic, his humour is of the rarest vintage, his style is like the vigour of a spring morning, and his constructive faculty is classical. "There could," says Professor Raleigh, "be no better school for a novelist than is afforded by the study of Fielding's plots." Those who have read their Gibbon will not need to be reminded of the following tribute of the historian to the novelist: "The nobility of the Spensers has been illustrated and enriched by the trophies of Marlborough, but I exhort them to consider the 'Fairy Queene,' the most precious jewel in their coronet. Our immortal Fielding was of the younger branch of the Earls of Denbigh, who drew their origin from the Counts of Habsburgh, the lineal descendants of Eltrico, in the seventh century Duke of Alsace. Far different have been the fortunes of the English and German divisions of the family of Habsburgh; the former, the knights and sheriffs of Leicestershire, have slowly risen to the dignity of a peerage; the latter, the Emperors of Germany and the Kings of Spain, have threatened the liberties of the Old and invaded the treasures of the New World. The successors of Charles V. may disdain their brethren in England, but the romance of 'Tom Jones,' that exquisite picture of humour and manners, will outlive the Palace of the Escurial and the Imperial Eagle of Austria."

That is eloquent praise and not exaggerated. Fielding is securely a classic; his novels are as charged with life to-day as when they first won the admiration of his contemporaries. Dr. Johnson considered "Tom Jones" vicious, though he was fascinated by "Amelia"; but if the former great novel is too indulgent to the frailties of man, it is an open question whether it may not be so and yet remain a work of sounder morality—certainly far less nauseating—than Richardson's "Pamela," in which we are supposed to witness "virtue rewarded," but a brand of "virtue" that will not bear analysis. Fielding has created a crowded gallery of memorable characters—the true test of the novelist—and student and general reader alike must read him, though neither will need compulsion to the task.

Sterne. In addition to Fielding, three other novelists are included among Thackeray's representative humorists of the eighteenth century. In the case of LAURENCE STERNE (b. 1713; d. 1768), however, a distinction is made with which most modern readers will agree. The distinction is that Sterne is a great jester rather than a great humorist. "He fatigues me with his perpetual disquiet and his uneasy appeals to my risible or sentimental faculties. He is always looking in my face, watching his effect, uncertain whether I think him an impostor or not; posture-making, coaxing, and imploring me." The author of "The Life and Opinions of Tristram Shandy, Gent." (1759-1767), and "A Sentimental Journey through France and Italy" (1765) owed much, doubtless, to an acquaintance with the works of Rabelais and Cervantes and Burton's "Anatomy of Melancholy" (1621); but, as Mr. Birrell has said, "Sterne is our best example of the plagiarist whom none dare make ashamed." Careless, usually, of his grammar, he can on occasion find the "only word." He is ribald, but not salacious. As a sentimentalist, he may be—he is—tedious and tiresome. His morals may be bad, but one doubts with Coleridge if they can do much harm to anyone who was not bad enough before. At the lowest estimate, Sterne is a great master of the art of telling a story in an interesting way

Smollett. "The Hogarth of English Letters" is a phrase applied to TOBIAS SMOLLETT (b. 1721; d. 1771). Like Fielding, Smollett commands respect because he was a hard worker. He had "the very deuce" of a temper, maybe; but he sustained many hard, unkindly blows of ill-fortune. He was a stout and manly-hearted Scotsman. Professor Masson includes "The Adventures of Roderick Random" (1748), "The Adventures of Peregrine Pickle" (1751), and "The Expedition of Humphrey Clinker" (1771), with "Joseph Androws" and "Tom Jones," as "novels as nearly as amusing as any we have" (1859). In them, he says, "for the first time British literature possessed compositions making any approach, in breadth, bustle, and variety of interest to that form of literature, always theoretically possible, and of which other countries had already had specimens in 'Don Quixote,' and 'Gil Blas'—the comic prose epic of contemporary life." In the novels of Fielding and Smollett is represented the kaleidoscope of life, whereas Richardson keeps the attention more intimate with the feelings of his chief characters. One of Smollett's assets is his


Samuel Richardson


John Bunyan


Henry Fielding


Tobias Smollett


Jane Austen


Laurence Sterne


Jane Porter


Maria Edgeworth


Madame d'Arblay

EARLY WRITERS OF ENGLISH PROSE FICTION

Scotticism; and though "Roderick Random" and "Peregrine Pickle" should cease to be read, Scotsmen, in the opinion of Professor Masson, "would still have an interest in preserving 'Humphrey Clinker.'" Like Fielding and Sterne, Smollett was a creator of types; but his own life affords a singular contrast to that led by some of his literary creations.

Goldsmith. Of Oliver Goldsmith (b. 1728; d. 1774) it has been said that *Virginibus puerisque* might have been his appropriate and uncontested motto. His one novel, "The Vicar of Wakefield," written though it was with a moral motive akin to that which induced Richardson to write "Pamela," is a work that stands alone. "There are a hundred faults in the thing," says the author in his preface; but as it has been wittily observed, a hundred things might plausibly be said to prove them beauties. The "charming prose idyll of dear Irish Goldy" may be described as both highly improbable and as intimately true to nature.

Written in 1761, "The Vicar of Wakefield" was not published till 1766. Professor Raleigh, who cites its admirable comedy as perhaps its highest merit, makes a very striking comment in his reference to this work: "The story of its discovery by Johnson, as told in Boswell, is one of the best known and most characteristic passages of Goldsmith's life. The picture of Goldsmith, arrested for debt, changing the guinea sent him by his friend for a bottle of Madeira, helpless and angry, while a completed novel, which sold at the first offer for sixty pounds, lay written in his desk, has often been employed to illustrate the improvidence of authors. It might be better used to illustrate the prudence of an author who was an improvident man. No one ever drew a firmer line between the works he wrote to last and the compilations that his necessities extorted from him than was consistently drawn throughout his life by Oliver Goldsmith. It did not occur to him to expect fame from his histories, political or natural. . . As little did it occur to him to treat his carefully wrought original works as so much merchandise, or a sop for the bailiff, and perhaps Johnson's kindly offices prevented 'The Vicar of Wakefield'

from receiving its full share of the correction and polish that Goldsmith bestowed on all his best work."

Minor Novels before "Waverley." Among the other novels which preceded "Waverley" (1814) must be named "The Adventures of David Simple," by SARAH FIELDING (b. 1710; d. 1768), the sister of the author of "Tom Jones"; "The Female Quixote" of CHARLOTTE LENNOX (b. 1720; d. 1804); "The History of Rasselas, Prince of Abyssinia," which JOHNSON wrote in 1759, partly to pay for his mother's funeral and partly in answer to the witty libertinism of Voltaire's "Candide"; the "Arundel" and "Henry" of RICHARD CUMBERLAND (b. 1732; d. 1811), an imitator of Fielding; "Chrysal; or, the Adventures of a Guinea" by CHARLES JOHNSTONE (b. 1719?; d. 1800?), whose vein was chiefly satirical, and whose quarry was political and domestic vice; "The Man of Feeling" and "Julia de Roubigné" by HENRY MACKENZIE (b. 1745; d. 1831), a follower of the sentimental methods of Sterne; "The Castle of Otranto," a "Gothic Romance," by HORACE WALPOLE (b. 1717; d. 1797), who, as Professor Masson says, did something to remind British readers that "there had been a time in the world when men lived in castles, believed in the devil, and did not take snuff or wear powdered wigs"; "The Old English Baron" of CLARA REEVE (b. 1729; d. 1807), whose crude style succeeded where that of Walpole failed; "The Romance of the Forest," "The Mysteries of Udolpho," and "The Italian" of ANN RADCLIFFE (b. 1729; d. 1807), the originator of the mysterious and fascinating blackguard in fiction—a truly Protean creation; "Hermsprong; or, the Man as He is Not" by ROBERT BAGE (b. 1728; d. 1801); "The Monk" of MATTHEW GREGORY LEWIS (b. 1773; d. 1819); the "Zeluco," of DR. JOHN MOORE (b. 1729; d. 1802); the "Vathek" of WILLIAM BECKFORD (b. 1759; d. 1844); the "Caleb Williams" and "Fleetwood" of WILLIAM GODWIN (b. 1756; d. 1836), one of the first of English writers to utilise the novel for political purposes; "A Simple Story" and "Nature and Art" by MRS. INCHBALD (b. 1753; d. 1821); the "Old Manor House" of CHARLOTTE SMITH (b. 1749; d. 1806); "The Fatal Revenge" and "Melmoth the Wanderer," by CHARLES ROBERT MATURIN (b. 1782; d. 1824), who possessed an almost uncanny power over the treatment of the supernatural; "Adeline Mowbray," by MRS. OPIE (b. 1769; d. 1853); the "Children of the Abbey" of REGINA MARIA ROCHE (b. 1764?; d. 1845); and last, but not least, the "Rosamund Gray" of CHARLES LAMB (b. 1775; d. 1834).

There is scarcely a novel we have named that is not worthy of the attention of the student, not always for its own sake but as a contribution to English fiction before the dawn of "Waverley." The general reader may be left to acquaint himself as his fancy leads and opportunity allows with some of the works included in this list.

Four Great Women Novelists. Before "Waverley" was published, four lady novelists had written works which attained a higher level as novels than perhaps any named in the above group.

FANNY BURNEY, MADAME D'ARBLAY (b. 1752; d. 1840), in "Evelina" and "Cecilia," had treated character with all the realism of Ben Jonson without the coarseness of that writer's dramatic "humours." To quote Mr. Austin Dobson, "'Evelina' marks a definite deviation in the progress of the national fiction. Leaving Fielding's breezy and bustling highway, leaving the analytic hothouse of Richardson, it carries the novel of manners into domestic life, and prepares the way for Miss Edgeworth and the exquisite parlour pieces of Miss Austen."

MARIA EDGEWORTH (b. 1767; d. 1849), whose delightful character finds eloquent expression in "Castle Rackrent." Her work applied a needed corrective to the passion for the weird and horrible romances which Mrs. Radcliffe, "Monk" Lewis, and others had made so popular, but which was to be aroused again in 1817 by the "Frankenstein" of Mary Shelley. Miss Edgeworth's Irish tales inspired the patriotic novels of Sir Walter Scott.

JANE AUSTEN (b. 1775; d. 1817) wrote six novels—"Sense and Sensibility" (1811), "Pride and Prejudice" (1812), "Mansfield Park" (1814), "Emma" (1816), "Northanger Abbey" (1818), and "Persuasion" (1818)—all of which, together with Fanny Burney's "Evelina" and "Cecilia," are frequently reprinted to-day. Macaulay suggested, Professor Goldwin Smith has adopted, and Professor Raleigh looks favourably upon, a comparison between Jane Austen and Shakespeare. This is derived partly from the absolutely impersonal character of her works. She tells us nothing about herself, and she is oblivious of the happenings in the great world beyond her own circle. She is a satirist minus indignation; hers is the quiet irony of the cultured mind; her subtle humour is only audible to the cultured ear. To study her books is to be given a series of invaluable lessons in the art of observation and in precision of detail. Miss Austen's method was appreciated by Scott. "The big bow-wow strain I can do myself, like any now going," said Sir Walter; "but the exquisite touch which renders ordinary commonplace things and characters interesting from the truth of the description and the sentiment is denied me." Miss Austen supplies a faithful picture of the English country life of her period. She gives us, as Mr. Dawson says, "the sort of details about the lives of average people which the historian omits and the sociologist demands."

JANE PORTER (b. 1776; d. 1850) wrote two novels that still retain a certain measure of popularity, "Thaddeus of Warsaw" (1803) and "The Scottish Chiefs" (1810). Both are eminently readable; and they entered a field which so far had been untrodden—the field of historical romance, the chief glories of which were soon to fall to Sir Walter Scott.

Continued

SHAFTS, AXLES, & COUPLINGS

Cottars, Shafts, Couplings, Journals. The Forces Acting on Shafts: Bending and Twisting. The Strength of Railway Axles

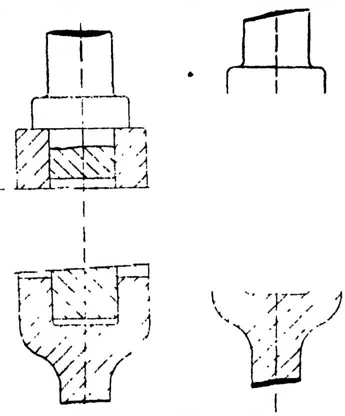
Group 8
DRAWING
22

Continued from page 3009

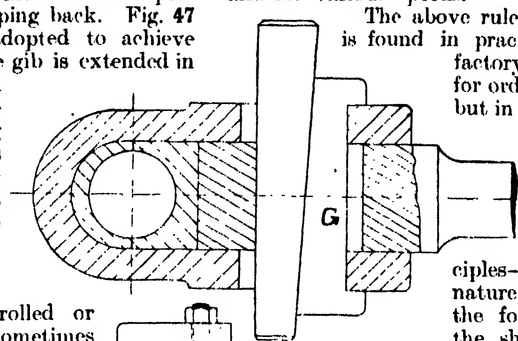
By JOSEPH W. HORNER

Cottars. A cottar is a tapered bar or wedge used for connecting ends of rods into sockets, or as a means of setting up bearing brasses, etc., to compensate for wear.

Fig. **45** shows a cottared joint in a rod, the width of the cottar is usually one and a quarter times the diameter of the rod, whilst the thickness is one quarter of the diameter; the taper of the cottar varies from 1 in 15 to 1 in 30. Fig. **46** illustrates a cottar applied to a connecting rod end where it is used for the purpose of adjusting the brass. The piece lettered G is termed a gib, and forms a guide or backing for the cottar. When it is necessary to make considerable allowance for the setting up of a brass, the taper of the cottar may be increased to as much as 1 in 6; but means must then be provided to prevent it from slipping back. Fig. **47** shows a common device adopted to achieve this object—the head of the gib is extended in circular form, and is screwed and fitted with nuts, the head of the cottar having a head forged on which is drilled to accommodate the screw. Further examples will be given when the design of connecting rods is discussed.

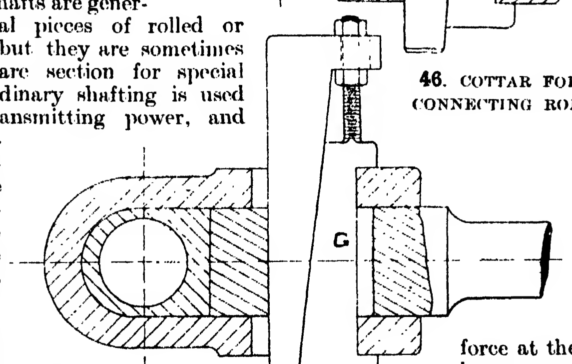


45. COTTARED JOINT



46. COTTAR FOR CONNECTING ROD

Shafts. Shafts are generally cylindrical pieces of rolled or forged steel, but they are sometimes made of square section for special purposes. Ordinary shafting is used for simply transmitting power, and is chiefly subject to twisting forces, the bending actions due to the pull of the driving belts being comparatively small. Engine crank - shafts and the shafts of hauling and hoisting machinery are subject to combined twisting and bending forces, and must be calculated accordingly. The axles of locomotives, railway carriages and trucks, motor-cars, etc., are subject to bending forces only except in the case of the axle or axles which are driven; they must be then calculated to withstand the twisting effect of the power transmitted as well as the bending action due to the wheel load.



47. COTTAR FOR CONNECTING ROD
Showing method of preventing slipping

Taking the case of ordinary shafting supported by bearings about 8 ft. apart, the diameter may be readily calculated by the following rule: Multiply the horse-power to be transmitted by 55, divide the result by the number of revolutions which the shaft makes in a minute, and extract the cube root of the quotient. A table is given on the next page of a number of shafts already calculated by this rule and for various speeds.

The above rule is empirical, and is found in practice to give satisfactory results when used for ordinary line shafting; but in cases where a shaft is subject to specially heavy belt drives its diameter should be calculated from first principles—that is to say, the nature and the amount of the forces acting upon the shaft should be estimated, and the shaft be proportioned to resist them.

Twisting Action. The twisting action on a shaft is measured in "inch-pounds," or in "inch-tons," as may be most convenient. Taking the case of a shaft driven by a pulley, say, 36 in. diameter, having a turning force at the rim of 350 lb., the "twisting moment," as it is termed, is $18 \times 350 = 6{,}300$ inch - pounds; the figures 18 being the radius in inches at which the turning force acts. The twisting moment on a shaft may also be easily determined from the horse-power transmitted and the speed in revolution per minute. Suppose

LINE SHAFTING

Speeds in Revolution per Minute

100	150	200	250	300	350	400
h.p.		h.p.	h.p.		h.p.	h.p.
6·7	10·1	13·5	16·8		23·6	27·0
8·6	12·8	17·1	21·5	25·8	31	34·3
10·7	16	21·5	26·8	32	39	43
13·2	19·7	26·4	32·9	39	46	52
16	24	32	40	48	56	64
19	29	38	48	57	67	76
22	34	45	56	68	80	90
27	40	53	67	79	94	105
31	47	62	78	93	109	125
41	62	83	104	125	145	167
54	81	108	134	162	189	216
68	103	137	172	205	240	273
85	128	171	214	257	300	342

CLAW COUPLINGS

Shaft Diam.	B	
	5½	4¾
	7	6
2½	8	7½
3	9	9
3½	10½	10½
4	11½	12
4½	13	13½
5	14	15
5½		
6	17	18

FLANGE COUPLINGS

Shaft Diam.	D	No. of Bolts.
1½		4
2		4
2½		4
3	11	5
3½	12½	5
4	14	6
4½	15½	6
	17	6
	18½	6
	20	6

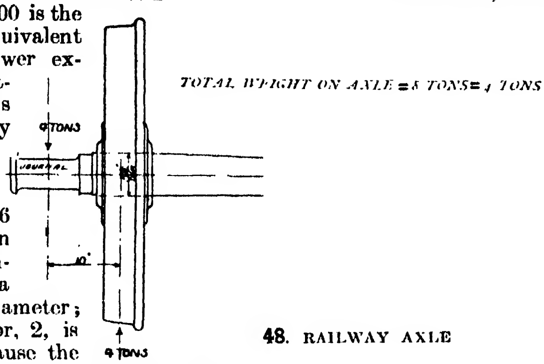
MUFF COUPLINGS.

Shaft Diam.		Shaft Diam.	B
1½		4	12
2	6	4½	13½
	7½	5	15
	9	5½	
		6	18

MOMENT OF INERTIA I AND MODULUS Z FOR SOLID CIRCLES

I for Bending	Z for Bending	I for Twisting	Z for Twisting
0·04900	0·09817	0·09817	0·1963
0·07863	0·1398	0·1573	0·2796
0·1198	0·1917	0·2397	0·3835
0·1755	0·2552	0·3509	0·5104
0·2485	0·3313	0·4970	0·6627
0·3431	0·4213	0·6862	0·8425
0·4604	0·5261	0·9208	1·052
0·6067	0·6471	1·213	1·294
0·7854	0·7854	1·571	1·571
1·001	0·9421	2·002	1·884
1·258	1·118	2·516	2·236
1·562	1·315	3·124	2·630
1·917	1·534	3·835	3·068
2·331	1·776	4·661	3·551
2·807	2·042	5·615	4·083
3·354	2·332	6·707	4·664
3·976	2·651	7·952	5·301
4·681	2·996	9·363	5·992
5·476	3·370	10·95	6·740
6·369	3·774	12·74	7·548
7·366	4·209	14·73	8·418
8·476	4·676	16·95	9·353
9·70	5·177	19·41	10·35
11·07	5·712	22·14	11·42
12·57	6·283	25·13	12·57
14·21	6·891	28·42	13·78
16·01	7·536	32·03	15·07
17·98	8·221	35·97	16·44
20·13	8·946	40·26	17·89
22·46	9·713	44·92	19·43
24·99	10·52	49·98	21·04
27·72	11·37	55·45	22·75
30·68	12·27	61·36	24·54
37·29	14·21	74·58	28·41
44·92	16·33	89·84	32·67
53·66	18·66	107·3	37·33
63·62	21·21	127·2	42·41
74·90	23·97	149·8	47·94
87·62	26·96	175·2	53·92
101·9	30·19	203·8	60·39
117·9	33·67	235·7	67·35
135·6	37·41	271·2	74·82
155·3	41·42	310·6	82·84
177·1	45·70	354·2	91·40
201·1	50·27	402·1	100·5
227·4	55·13	454·8	110·3
256·2	60·29	512·5	120·6
287·7	65·77	575·5	131·5
322·1	71·57	644·1	143·1
359·4	77·70	718·7	155·4
399·8	84·17	799·6	168·3
443·6	90·99	887·2	182·0
490·9	98·17	981·7	196·3
541·8	105·7	1,084	211·4
596·7	113·6	1,193	227·3
655·6	122·0	1,311	243·9
718·7	130·7	1,437	261·3
786·3	139·8	1,573	279·6
858·5	149·3	1,717	298·6
935·7	159·3	1,871	318·5
,018	169·6	2,036	339·3

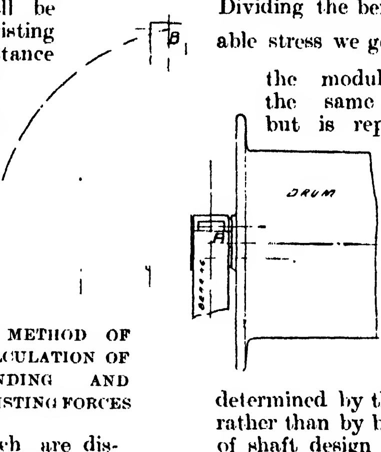
that a shaft is to transmit 20 horse-power at a speed of 120 revolutions per minute, the twisting moment $= \frac{20 \times 33000 \times 12}{120 \times 3\cdot1416 \times 2} = 10{,}504$ inch-pounds; 33,000 is the mechanical equivalent of a horse-power expressed in foot-pounds, and is multiplied by 12 to reduce it to inch-pounds; 3·1416 is the relation of the circumference of a circle to its diameter; the last divisor, 2, is necessary because the twisting moment is measured radially.



48. RAILWAY AXLE

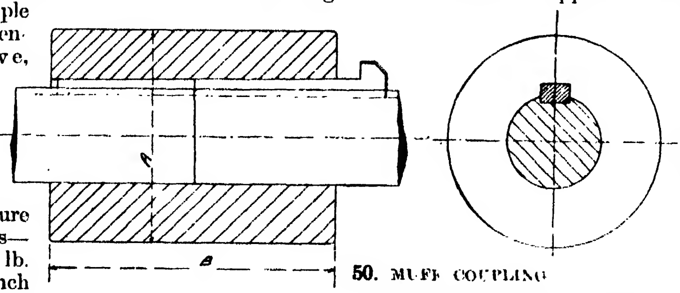
The Resistance of a Shaft to Twisting. In the same way as we may define a twisting moment acting on a shaft, so we may formulate a "moment of resistance" of the shaft itself which shall be equal and opposite to the twisting moment. The moment of resistance of a shaft to twisting is found by multiplying the "modulus for twisting" by the greatest allowable "stress" per square inch; the modulus for twisting is a mathematical function of the diameter of the shaft, and is represented by the formula $\frac{d^3\ 3\cdot14}{16}$ where d = the diameter of the shaft. A table of the moduli of various diameters with "moments of inertia" and "modulus" for bending is given on the opposite page, the use of both of which are discussed later. The greatest allowable stress per square inch depends upon the material of the shaft and upon the factor of safety decided upon. A safe stress for steel shafts is 10,000 to 12,000 lb. per square inch, which allows a factor of safety of about 5 or 6 to 1. Selecting as an example the shaft mentioned above, where a twisting moment of 10,504 inch-pounds was calculated, we divide that figure by a safe stress—say, 10,000 lb. per square inch $= \frac{10{,}504}{10{,}000} = 1\cdot05$ modulus, which, upon referring to the table of modulus for twisting, we find is equal to 1¾ in. diameter.

Bending Actions on Shafts. The bending action on a shaft is measured in the same units as a twisting action—*i.e.*, inch-pounds or inch-tons; but instead of a twisting or shearing tendency being set up, there is a tendency to snap the shaft off by crushing the fibres on one side and tearing them apart on the opposite side. A typical example occurs in an ordinary railway waggon axle [48], where the load on the journal is transmitted to the wheel by the axle; the "bending moment" is here 4 tons × 10 in. = 40 inch-tons. Railway axles, on account of the heavy shocks they are frequently subjected to, must have a large margin of safety, not less than 9 to 1, equal to 3 tons per square inch for mild steel. Dividing the bending moment by this allowable stress we get $\frac{40}{3} = 13\cdot3$ modulus. Now, the modulus for bending has not the same value as for twisting, but is represented by the formula $\frac{3\cdot1416}{32}$ the table gives these moduli worked out for a number of different diameters. The figure we have arrived at, 13·3, is equal to, say, 5⅛ in. diameter, which, of course, is in the wheel seat. The diameter of the axle in the journal is more frequently determined by the pressure per square inch rather than by bending stress, but this view of shaft design will be dealt with when we come to journals. It will be noted that in the table of moduli, etc., the letter I is given for the moment of inertia and the letter Z for the modulus; these letters are the recognised standard symbols for the terms.



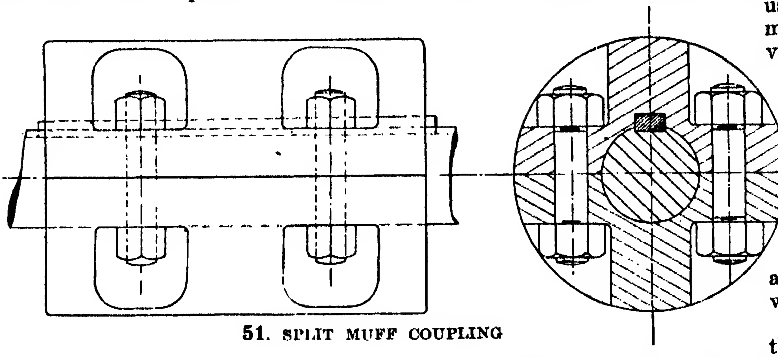
49. METHOD OF CALCULATION OF BENDING AND TWISTING FORCES

It sometimes happens that a shaft is subjected to a combination of the above actions of bending and twisting at one and the same time; any shaft which receives or transmits power by a pulley, crank, or wheel on an overhanging end comes under those conditions. An example is shown in 49, which represents a spur wheel driving the drum shaft of a hauling gear. The twisting moment and the bending moment



50. MUFF COUPLING

must be so combined in calculation as to enable either one or the other modulus to be used. A simple and interesting method is as follows: From point A, the centre of the

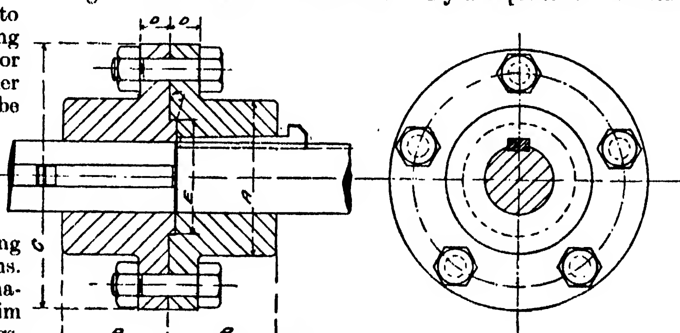


51. SPLIT MUFF COUPLING

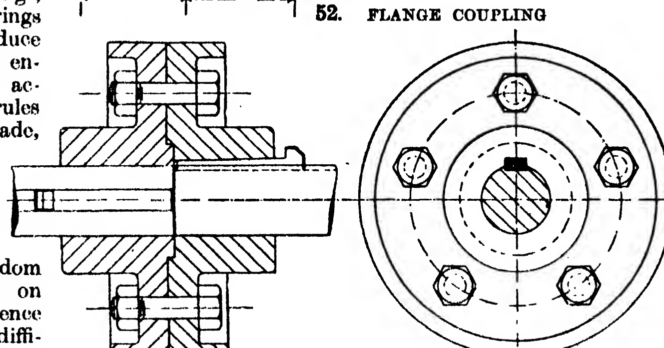
bearing, describe an arc B C, bisect the horizontal line C D at E, then multiply the pressure or load at B by the distance E A; the result gives an equivalent bending moment to the combined actions, and the modulus for bending may be used. Or by calculation:

$$M = \tfrac{1}{2} B + \tfrac{1}{2} \sqrt{B^2 + T^2},$$

where M is the combined moment, B is the bending moment, and T is the twisting moment. This principle may be followed out for any combination of bending and twisting actions which a shaft may have to sustain. In some cases shafting may be loaded by pulleys or gear-wheels in the same manner that a beam or girder may be loaded [see MATERIALS AND STRUCTURES, page 1984 to page 1987]; but if the above principles be thoroughly grasped, the student will find no difficulty in dealing successfully with such problems. Naturally, in designing machinery, it is a constant aim to keep all pulleys, couplings, etc., as close to the bearings as possible in order to reduce bending moments. Marine engine shafts are calculated according to empirical rules issued by the Board of Trade, Lloyd's Survey, etc., and are dealt with in a later article on engine details; hollow shafting is also discussed later.



52. FLANGE COUPLING



53. PULLEY COUPLING

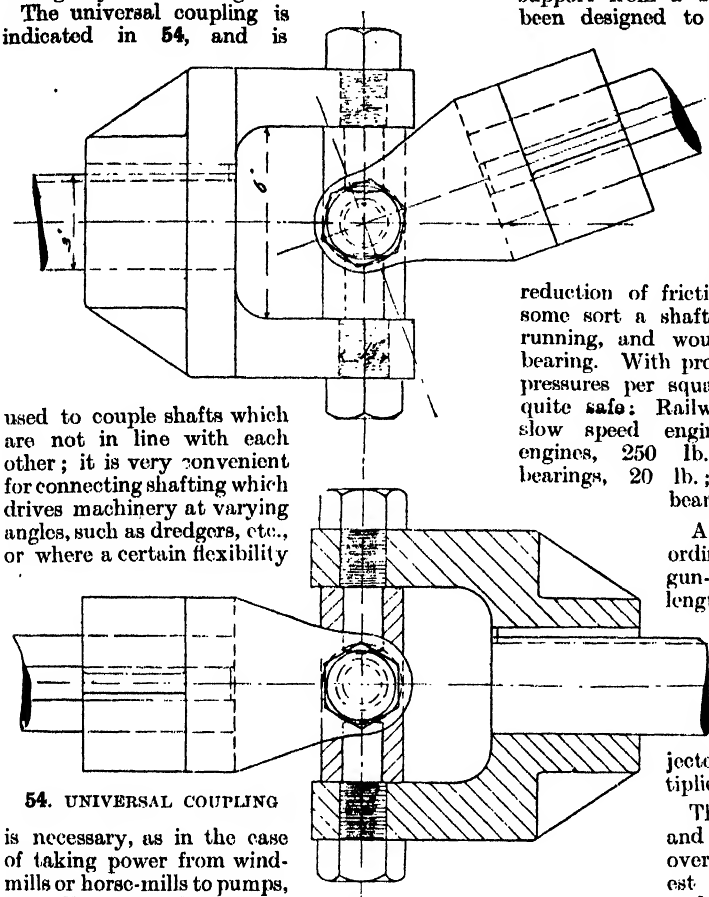
Couplings. A shaft seldom exceeds 30 ft. in length on account of the inconvenience of manufacture and the diffi- at de- vised to joint or couple them together in convenient lengths. The simplest form of coupling is the muff or box coupling [50], which is simply a cast-iron sleeve bored out to fit the shafts and keyed thereon. Two keys are used, and they are both driven from the same end; the shafts butt against each other in the middle of the coupling. A table is given on page 3134 of the usual proportion of muff couplings for various sizes of shafts.

The split muff coupling is shown in 51. It has the advantage that it is easily fitted or removed; a single feather key is used, and the muff is bored so as to grip the shaft when bolted together.

Fig. 52 illustrates the most widely used form of coupling. It is termed a flange coupling and consists of cast-iron bosses with flanges. The bosses are keyed to the ends of the shafts and the flanges are bolted together, a projection being formed on one half coupling to fit in a corresponding recess formed in the other half; this device ensures the correct alignment of the joint. A table is given of dimensions of flange couplings. Fig. 53 shows a similar coupling, but the outside diameter of the flanges is increased and also widened to protect the boltheads and nuts. By this provision accidents such as the catching of a workman's clothes, etc., are prevented; a coupling may also do service as a driving pulley when made in this latter form.

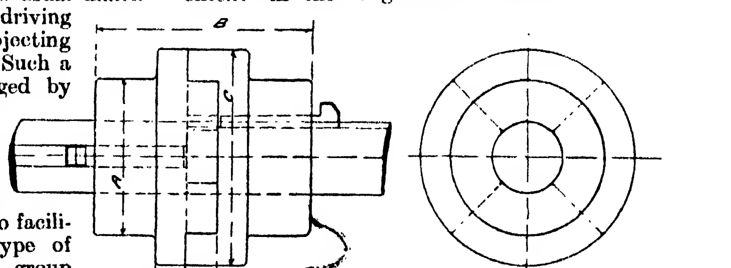
In cases where there must be no risk whatever of a breakdown—marine engine work for example—the coupling is formed by forging the flanges on the ends of the shafts themselves, and so eliminating keys and castings.

The universal coupling is indicated in **54**, and is used to couple shafts which are not in line with each other; it is very convenient for connecting shafting which drives machinery at varying angles, such as dredgers, etc., or where a certain flexibility is necessary, as in the case of taking power from windmills or horse-mills to pumps, etc. The example given is for a shaft 3 in. in diameter; the pivot pins are half the diameter of the shaft, and the width of the jaw is twice the diameter of the shaft.



54. UNIVERSAL COUPLING

Claw Couplings. A class of coupling which is readily uncoupled is illustrated in **55**, and a table is given on page 3134 of its usual dimensions; no bolts are used, but driving is effected by means of projecting claws which mutually engage. Such a coupling can be easily disengaged by drawing the key and pulling the claw faces apart; when this process is frequently required it is usual to make one half of the coupling to slide on a feather key and to arrange lever gear to facilitate the withdrawal. This type of coupling brings us to a larger group known as "friction clutches," but which are virtually couplings that can be engaged and disengaged whilst the shafting is in motion. They will be dealt with in a subsequent article after we have completed the delineation of the simpler elements of mechanism.



55. CLAW COUPLING

Journals. A journal may be described as that portion of a shaft or axle which receives support from a bearing. After a shaft has been designed to have sufficient strength to transmit the loads imposed upon it, it is necessary to see that ample area is provided in its journals in order to ensure cool and efficient running. A journal must have sufficient area to dissipate the heat generated by the friction between it and its bearings. Good lubrication is a great factor in the reduction of friction; without a lubricant of some sort a shaft would rapidly heat whilst running, and would soon grip or seize the bearing. With proper lubrication the following pressures per square inch of journal area are quite **safe**: Railway axles, 150 to 260 lb.; slow speed engines, 500 lb.; high speed engines, 250 lb.; ordinary shafting, iron bearings, 20 lb.; ordinary shafting, brass bearings, 40 lb.

A good rough rule for an ordinary journal revolving in a gun-metal bearing is to make the length $1\frac{1}{2}$ to $1\frac{3}{4}$ times the diameter; with cast-iron bearings the journal length may be $3\frac{1}{2}$ to 4 times the diameter. The area of a journal, or a bearing, is calculated as the projected area—*i.e.*, diameter multiplied by length.

The pressure between a journal and its bearing is not constant over the entire area; the greatest intensity occurs directly under the centre of the load, and it decreases circumferentially to zero at the half diameter. This is not considered when calculating the size of a journal in accordance with the preceding rules. There is also a similar variation in pressure—though to a much less extent—in the longitudinal direction; but a mean pressure per square inch over the whole area is assumed.

Continued

THE ETHERS AND THEIR USES

Ethers and Other Organic Compounds. The Nature and Value of the Ethers, Esters, and Mercaptans and Amines. The Various Kinds of Alcohols

By Dr. C. W. SALEEBY

PURE acetic acid is sometimes spoken of as a colourless liquid, and sometimes as a colourless solid, since below 17° C. it is solid, and is then called *glacial acetic acid*. It readily mixes with water, ether, and alcohol, and is useful as a solvent. The acid has a number of uses, both in medicine and in manufactures. In consequence of its affinity for water, glacial acetic acid has a marked caustic action upon the skin. It is sometimes employed also for the destruction of small warts and corns. Weak solutions of acetic acid or pleasantly scented vinegar are agreeable applications to the skin, which they tend to cool as well as to free from the unpleasant defects of excessive perspiration. It is stated in a well-known work of reference that acetic acid "is used in medicine to relieve nervous headaches and fainting fits," but this statement has really no relation to medicine of the present day, in which it is certainly not so employed. The acid has considerable uses in relation to calico printing, and is employed in the preparation of its salts, the acetates, which are of considerable importance in commerce.

The Ethers. If the reader will contemplate the little table to which we have already referred, and will compare the first and second columns, he will be able to remind himself of what we have already stated, that from one point of view the paraffins may be looked upon as analogous to metals, and the alcohols as none other than the hydrates of those metals, one of the hydrogen atoms having been replaced by the hydroxyl group OH. Now, if this manner of looking at these compounds be justified and not dependent merely upon a superficial resemblance, we ought to be able to carry the comparison a little further. If the paraffins are so much like metals as to form hydrates, they ought also to form oxides. If the hydrate is really a hydrate, it ought to be possible to remove from it the constituents of water and to leave the oxide behind. Now, this is possible. The term *ether* is a generic name used in organic chemistry for such oxides, and we might have inserted in our table [page 3020] a fifth column, showing the relationship of the ethers to the other four. What, then, will be the formula of the ether derived from methane? Plainly, in order to remove the constituents of water from methyl alcohol, the group CH_3 being regarded as a unit which must not be broken, we must take two molecules and abstract H_2O from them. This will give us a body having the formula $(CH_3)_2O$. Similarly, in order to form the ether or oxide from ethyl alcohol, one has to take two molecules and subtract the constituents of water from them; the body thus resulting must have the formula $(C_2H_5)_2O$. These simple examples correspond to bodies which really exist. If now we try to state the matter in more abstract terms, we may say that, if we use the symbol R to represent a one-handed or monovalent hydrocarbon radical (such as the methyl radical CH_3), then the structure of an ether is represented by the formula ROR. An ether having such a constitution is technically called a simple ether. In the case of methyl ether, which is a simple ether, ROR is plainly equivalent to CH_3OCH_3. On the other hand, we need not necessarily have the same hydrocarbon radical repeated in the structure of the ether. The one might be the methyl radical, and the second the ethyl radical. The best general way of expressing the construction of such an ether would be ROR_1. An ether which contains two radicals in this fashion is conveniently distinguished as a mixed ether.

Chemistry and the Simplicity of Nature. It must surely have struck the reader that there is a remarkable simplicity underlying the apparent complexity of our subject. It is true that we are using long and complicated formulæ, which would have alarmed us very much, and very naturally, had we been introduced to them a few months ago. But, on the other hand, these formulæ undergo transformations in a very intelligible way, and, so far, possess relations with one another which can scarcely be forgotten. Indeed, this character of the organic compounds is sometimes almost conspicuously to be contrasted with the apparently arbitrary and capricious facts which we have often encountered in our study of inorganic chemistry. Here we are dealing, not with the theory of knowledge, but with a certain part of the subject matter of knowledge; yet, since all knowledge is one, we may be excused, even here, for pointing out the significance of the simple and reasonable relationships which rule the complexities that we are now studying. It may be doubted whether there is any study in the world which teaches us more clearly than organic chemistry, first of all, that, apparent or real complexities notwithstanding, the capricious and the arbitrary have no real existence, and, secondly, the truth of the great dogma of philosophy, that *Nature is intelligible by man's intelligence*. This is a simple statement and may sound like a jingle, but, if it be true, it is one of the greatest of all truths, and if it were false it would be one of the greatest of all falsehoods.

Alkyls. Perhaps the most convenient fashion in which to prepare the ethers is by the action of the iodide of methyl, ethyl, etc.—these radicals being ranked under the generic name *alkyls*—on the sodium compound of an alcohol. Thus,

for instance, when the iodide of methyl acts upon the sodium compound of methyl alcohol (the formula of which is simply that of methyl alcohol with the sodium atom in place of the hydrogen atom of the hydroxyl group) sodium iodide and methyl ether are produced. This statement really takes much longer to write or read than to understand. The reader should write the equation representing this decomposition for himself, and he will see how simple it is. Plainly, the methyl group of the iodide changes places with the sodium atom, and the thing is done. There are several other general reactions by which ethers may be prepared. Methyl ether, the formula of which we have already given, may be readily prepared from methyl alcohol, and is a gas above the temperature of $-21°$ C. If we start with a mixture of methyl and ethyl alcohols, we naturally enough obtain a mixed ether, which is called by the very explanatory name, *methyl-ethyl ether*, and with the formula of which the reader need not be insulted. This body boils at 11° C.

Characters of Ethers. In a moment we shall discuss the most important of the ethers; meanwhile, we note that, in general, these bodies are very mobile, colourless liquids, usually having a characteristic odour, while the higher ethers are white crystalline solids. The mobility of any of the lower ethers is striking, and the different characters of different liquids in this respect cannot be illustrated to the student of physics better than by three bottles containing respectively ether, water, and oil. The ethers are either insoluble or only very slightly soluble in water. In general the ethers are capable of oxidation and then form organic acids. They are, of course, combustible. One says "of course," since it is assumed that the reader will argue deductively from his knowledge of the constitution of the ethers. But in actual practice people sometimes forget, and the most lamentable accidents have followed upon carelessness in the use of ordinary ether in surgery and elsewhere. It looks more or less like water and causes forgetfulness of its properties. (The reader knows, of course, why water cannot burn.) If the ethers be heated with water in sealed tubes, an action which might have been expected occurs, recombination taking place and the alcohols being formed.

Sulphuric Ether. We have placed at the head of this paragraph the common name of what is by far the most important of all the ethers. It is commonly known as *ether*, and it is as such that we shall refer to it here. There is no proper warrant whatever for the name sulphuric ether, which gives one, at first, an entirely erroneous conception of its structure, and which is applied to it merely because sulphuric acid is employed in its manufacture. Its proper chemical name is *ethyl ether*, and its formula has already been stated. The process of its manufacture is typical of what is called *etherification*. This term is usually applied to the commercial manufacture of ether from alcohol and sulphuric acid. The reactions are very interesting. The first change which occurs —under the conditions about to be stated—is an interaction between the alcohol and the sulphuric acid, with the formation of water and the body which has the formula $C_2H_5HSO_4$. This is sometimes known as *ethyl sulphuric acid*, or may be called a *hydrogen alkyl sulphate*. When this body is further distilled with alcohol, sulphuric acid is formed again and ether distils over. The reader should write out for himself the equations representing these two actions. He will find them extremely simple, only one molecule being required in each term. It will be found in the case of the first equation that the reaction causes the isolation of one molecule of water. If the reader does not follow our advice to write out the equations for himself, our policy of not stating them in full will have been rendered useless.

Process of Etherification. The following account of the actual fashion in which the continuous process of etherification is performed we quote from Sir Wm. Ramsay:

"In actual operations a mixture of alcohol and sulphuric acid is heated to 140 degrees in a capacious flask, and a slow stream of alcohol is run in; ether mixed with water and alcohol distil over continuously; hence this process is termed the *continuous etherification process*. A limited quantity of sulphuric acid should theoretically convert an unlimited amount of alcohol into ether; but, in practice, some of the sulphuric acid is reduced to sulphur dioxide, which distils over with the ether. To remove it, the ether is shaken with caustic soda solution, and to remove alcohol it is shaken many times with water. The surface layer of ether is then removed, dried by adding lumps of fused calcium chloride and leaving it to stand, and is finally redistilled from phosphorous pentoxide."

The ether thus formed has the characters belonging to its series. It boils at about 35° C., and the vapour which it gives off at this quite low temperature is extremely inflammable, like the liquid itself. Not infrequently people remember that the liquid is inflammable, but forget the danger which attaches to its vapour. Ether is very slightly soluble in water, but readily mixes with alcohol and chloroform. A mixture of these three substances is known as A.C.E. mixture, and is very frequently used as an anæsthetic in surgery. Ether is one of the most important of solvents, and notably so for fats. This gives it another value for the surgeon, who often uses it in order to remove from the skin its natural fat, in which bacteria multiply so abundantly. Ether also dissolves resins, and is much used for this purpose in chemistry and in pharmacy. Owing to its extremely rapid evaporation at relatively low temperatures, ether affords a very effective means for the production of extremely low temperatures. The reader will recall the application of this property of evaporation in a physical instrument.

The Practical Use of Ether. But, after all, the most important and interesting of all the uses to which ether is put is as an anæsthetic. A long time ago we had occasion to refer to nitrous oxide, N_2O, which may fairly be called

the oldest anæsthetic—at any rate it has the first place in the modern history of anæsthesia. It was first inhaled by Sir Humphry Davy in the year 1800, and he suggested its employment in surgery: "As nitrous oxide in its extensive operation seems capable of destroying physical pain, it may probably be used with advantage in surgical operations in which no great effusion of blood takes place." Thus the great chemist did his duty in calling the surgeons' attention to the matter; but they paid no attention to the suggestion. Eighteen years later another illustrious chemist and physicist, Faraday, proved that ether, like nitrous oxide, produces anæsthesia.

The "Chemistry of Consciousness." Even then, however, such is conservatism at its worst, surgeons made no response. It was not until 1846 that Morton, a dentist at Boston, successfully administered ether for the extraction of teeth and for other operations. Two or three months later, Sir James Simpson made the first employment of ether in cases of childbirth, and followed this up after a very short time by the discovery of the anæsthetic value of chloroform. In the case of nitrous oxide we made a point of showing that a chemical explanation can be afforded of its anæsthetic properties, and also of the very great safety which attends its use. It must positively be insisted that, beyond all question, a chemical explanation must also be expected to account for the arrest of consciousness by the inhalation of ether into the blood. But in this case we are as yet quite at a loss to offer this explanation. It is scarcely surprising if we remember that the chemistry of consciousness is yet entirely unknown; indeed, so far as the present writer knows, this is the first occasion on which the phrase has been employed.

An interesting example of the use of ether in dissolving the most intractable of substances may be found in the preparation which is called *collodion*. Cotton-wool is subjected to the action of sulphuric and nitric acid, producing the substance known as *pyroxylin*. This is dissolved in a mixture of ether and alcohol, and is then known as *collodion*. A large number of other substances may be included for special purposes. When this is painted upon the skin the ether rapidly evaporates, the pyroxylin being precipitated in the form of a thin protective film, which has many useful functions.

Ethereal Salts. We may actually go yet a little further in our discussion of the analogy between the paraffins and metals. We have said that an alcohol is a hydroxide or hydrate, and that an ether is the corresponding oxide. If, then, we have ethyl hydrate and ethyl oxide, why should we not have, for instance, ethyl nitrate; in other words, if the analogy be more than superficial, the ethers should act like other oxides and form salts, and, in fact, they do so. These salts may be called *ethereal salts*, or they may be called *compound ethers*—a term which introduces confusion with "mixed ethers"—or they may be called *esters*. This term is now widely employed. An ester, then, is a salt in which the base is derived from a paraffin. The term is best confined to the ethereal salts of organic acids.

The salts formed by interaction between ethers or alcohols and inorganic acids may be briefly dismissed. Reference has already been made to the halides of methyl and ethyl. Similarly, many other organic acids have formed corresponding salts. The nitrates, sulphates, phosphates, etc., of various alkyls, or alkyl radicals are well-known. The common manner of their formation is by the action of the acid on the alcohol. One of the most familiar substances is *ethyl nitrate*, which is often known as *nitric ether*. Another, which is of considerable value in medicine, is the *nitrate of ethyl*, which is a highly inflammable, mobile liquid with a very pleasant, fruity odour and taste. Its characteristic interactions with the body, however, are those of a nitrite—in other words, they depend upon the acid rather than the basic part of its constitution. The familiar drug known as *sweet spirits of nitre*, owes all its value to ethyl nitrite, of which it contains about two per cent., together with a large number of impurities. Properly, sweet spirits of nitre should be abolished from the Pharmacopœia, and its place taken by the pure solution of ethyl nitrite.

Of the esters, properly so-called, little more need be said. Perhaps the best known is *ethyl acetate*, the formula of which is that of acetic acid, already quoted, the ethyl radical being substituted for the final H of that formula. This body is often known as *acetic ether*, and has a very pleasant odour. This last character is common to most of the esters, which are therefore very often employed in sweetmeats, and upon which depends the characteristic fragrance and taste of many fruits and wines.

The Mercaptans and their Products. Yet further may we carry our proof of the rational character of organic chemistry. Long ago we saw that sulphur and oxygen, widely though they differ in their physical characters, yet have a definite chemical resemblance to one another, and may be treated as a pair of allied elements. The simplest possible illustration of this is to be found in the resemblance between the formulæ of water and of sulphuretted hydrogen, H_2O and H_2S. Now, in accordance with the truth that there are not two chemistries but one chemistry, the same holds good in the case of organic compounds. It ought to be possible to form compounds analogous to the alcohols, but having sulphur in place of their oxygen atom. This is indeed so. The various members of the series of mercaptans are colourless liquids, almost insoluble in water, and having an extremely objectionable smell, such as is so often associated with the compounds of sulphur. The second mercaptan, to take an instance, is known as *ethyl hydrosulphide*, and has the formula C_2H_5SH. This shows at a glance its relation to ordinary alcohol. The peculiar name applied to these bodies is derived from a phrase expressing their *apt*itude to act upon *mercury*, or rather upon mercuric oxide.

They form a series of compounds, in which an atom of mercury takes the place of the hydrogen of the SH group.

It might reasonably be expected that the various alkyls would form sulphides analogous to the oxides or ethers which we have already studied, and this is so. If an S be substituted for the O of the formula of ether, we have the formula of ethyl sulphide, which, as might be expected, is characterised by its horrible smell.

If the hydrosulphides of the alkyls—the mercaptans—be oxidised, they yield a series of acids which are known as the *sulphonic acids*. A study of certain of these proves that there are really two distinct varieties of what we have hitherto referred to under the single name of sulphurous acid.

The Two Kinds of Nitrous Acid. As to this, we need not go any further, since the case is the same with nitrous acid, as we are about to show. If we take the iodide of an alkyl—as, for instance, ethyl iodide—and heat it in the company of nitrite of silver, we get a double decomposition which results in the formation of iodide of silver and what, from the appearance of its formula, ought to be ethyl nitrite. And, indeed, it is entitled to the name of ethyl nitrite, but it is by no means the same substance as that which we have already described under this name. The equation representing its formation reveals no distinction. It runs, of course, thus:

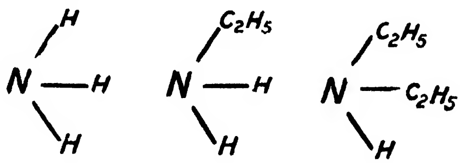
$$C_2H_5I + AgNO_2 = C_2H_5NO_2 + AgI.$$

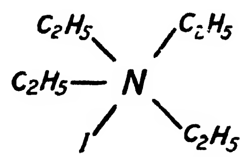
But, as a matter of fact, the ethyl nitrite thus formed has a boiling point of 112° C., whereas that already described has a boiling point of 16·4° C. Plainly, they are "the same but different," and we shall soon see that this sameness with a difference is an illustration of *isomerism*. The two bodies are called *isomers* because they have "equal parts." The shortest statement of the formula expresses this; the molecule of each consists of the same numbers of the same atoms. If, then, two substances have "equal parts," but are not the same, there is only one explanation of the difference—it is that the parts are differently put together. We can only conclude, then, that the NO_2 group is not the same in the two cases. The question is to find out where the difference lies.

Reactions of the Two Substances. We can do this by comparing the reactions of the two substances. Ordinary ethyl nitrite, under the influence of caustic potash, yields potassium nitrite and ethyl alcohol. This new ethyl nitrite, however, acts differently, the potassium atom of the caustic potash changing places with one of the hydrogen atoms of the nitrites so as to yield water and a new body, the formula of which the reader can write for himself. Furthermore, if this new ethyl nitrite be subjected to the action of nascent hydrogen, it forms a new substance, which we shall shortly study, called *ethylamine*; in this respect, also, it acts differently from ordinary ethyl nitrite. We must therefore no longer call this body ethyl nitrite, but must give it a new name, *nitro-ethane*; and we must find in the differences between it and true ethyl nitrite materials which lead us to conclude that there are really two nitrous acids; the formula of one may be written HONO, and of the other HNO_2.

The preceding paragraph has an importance greater than that of the particular statements which it contains. It teaches us to understand the dangers of brevity, or, to be more explicit, the dangers of statements so summary that they cloak important distinctions. The formula HNO_2 is thus too summary to be accepted without criticism. We have to recognise that it may stand for either of two molecules which are, indeed, isomeric, or have equal parts, but which are not identical any more than the state of affairs when the cards are dealt at whist is always identical because the same fifty-two cards are present in every case, or any more than vile and veil are the same word because they are composed of the same letters.

The Amines. We have seen that one of the arguments for the true character of nitro-ethane is derived from its behaviour with nascent hydrogen. The substance produced, ethylamine, has the formula $C_2H_5—NH_2$, and may be taken





as typical. It may be looked at in two ways, as the formula indicates. On the one hand, we may say that it is no other than a substituted ammonia—that is to say, it is simply ammonia which has had one of its hydrogen atoms exchanged for the ethyl group. This is a fair way of looking at it, and is justified by the fact that ethylamine and ammonia closely resemble one another. For instance, just like ammonia, ethylamine unites with hydriodic acid, forming ethyl ammonium iodide. The formula of this body is $CH_2—CH_3—NH_3I$. That has a formidable appearance, but it was certainly not worth writing down for the student who has carefully followed each stage in the preceding argument. Just as ammonium chloride yields ammonia when acted upon by caustic soda, so ethyl ammonium iodide yields ethylamine under a similar influence. Further complexities, which are not difficult to understand, are yielded if we adopt means for doubling the number of ethyl groups. For instance, if we heat ethylamine and ethyl iodide we obtain a compound which, when treated with caustic potash, gives us diethylamine. The first ethylamine we should really have called *monethylamine*. We can go on much

further in this direction, producing the hydriodide of triethylamine, and may go even further still. The accompanying graphic formulæ, in the first three of which nitrogen is three-handed and in the fourth five-handed, show us the relation of these various substances to ammonia. The last body of which the formula is drawn has the apparently formidable name *tetrethyl*—that is, four ethyl—*ammonium iodide*.

On the other hand, we may with equal propriety look upon the amines as substituted ethane. It is just as correct to look upon ethylamine as ethane, of which one hydrogen atom has been replaced by NH_2, as it is to call it ammonia, of which one hydrogen atom has been replaced by C_2H_5. Many amines are known to occur in nature, and many more have been prepared. They all smell very like ammonia.

The "Reasonableness" of Organic Chemistry. Lastly, we may note that our old statements as to the nitrogen group find support even in this field. If those statements were valid, we might expect to find a group of for instance, phosphines and arsines, corresponding to the amines ; and this is so.

So reasonable is organic chemistry, so intelligible by man's intelligence, that it is constantly yielding the most remarkable confirmations of *à priori* reasoning. Time and again the chemist says " there ought to be such and such a compound ; it ought to have such and such characters ; it ought to be capable of preparation in such and such a way." And when he sets to work he finds his predictions verified.

Even yet we have not adequately discussed the many products of the paraffins, and the main facts of a few more of these must be considered.

Some New Alcohols. We have already discussed a whole series of alcohols in general, and the most important member of that series in particular. We have seen that these alcohols may be regarded as analogous to hydrates or hydroxides. We have now to learn that this series of alcohols is not the only one. There are also two other series which must be named, though they are not of so great importance. The series to which ordinary alcohol belongs are more properly to be called the *primary alcohols*. There are also *secondary* alcohols and *tertiary* alcohols, according as two or three, instead of one, hydrogen atoms are replaced by alkyls. These have very similar properties, and also form intelligible series. One of the means of obtaining primary alcohols consists, as we are already in a position to understand, of the addition of hydrogen to aldehydes, which are dehydrogenised alcohols. We have now to learn that just as the *aldehydes* correspond to the *primary alcohols*, so there correspond to the *secondary alcohols* another series of bodies which are nearly related to the aldehydes, and are called *ketones*. All these alcohols—primary, secondary, and tertiary—we must note, are really no more than three groups of one particular class of alcohols which are called *monohydric*.

Dihydric Alcohols. In the monohydric alcohols only one atom of hydrogen of the original paraffins has been replaced by the hydroxyl group—OH. This is why they are called *monohydric*, or one hydric. Now, there is no *à priori* reason why it should not be possible to replace a second of the hydrogen atoms by hydroxyl. All the hydrogen atoms of methane, for instance, are identical in their relations within the atom. There is no reason why any one of them, rather than any other, should be replaceable by hydroxyl. The dihydric alcohols, then, are those which contain a second hydroxyl group. There are two kinds of these dihydric alcohols, as might be expected if we looked at the graphic formula of a paraffin. We should then see that a dihydric alcohol might be formed, in which one and the same carbon atom had both hydroxyl groups attached to it, while, on the other hand, the hydroxyl groups might be attached to different carbon atoms. The first group are called *aldehydrols*, and the second are called *glycols*. One or two examples of these bodies may be noted.

Chloral. Everyone, unfortunately, has heard of this powerful hypnotic, the use of which is attended with so many dangers of forming an incurable and fatal habit. The full name of chloral is *trichloraldehyde*. When this body unites with water it forms an aldehydrol, which is indeed the best known member of the series. (It is really the chlorine compound of the aldehydrol.) This aldehydrol, formed by the union of chloral and water, has the alternative name of chloral hydrate. In medicine and in common speech it is usually known merely as *chloral*, but that, of course, is incorrect ; the substance is not chloral or trichloraldehyde, but is that body plus water. In other words, it is an *aldehydrol*.

This, then, is the second substance, the reader may have noted, which contains chlorine, and which has a peculiar action upon the nervous system—chloroform, of course, being the other. Now, it is a remarkable fact that many others may be added to these two. For instance, methyl chloride, ethyl chloride, and several allied substances containing chlorine are either anæsthetics (general or local) or hypnotics, or combine both actions. This is a series of facts which obviously points to some larger meaning that will doubtless be familiar to the chemist of the future. We might venture to lay down the generalisation that the chlorine derivatives of the paraffins tend to interfere with the activities of nervous tissue. But the chemical explanation of this fact is not yet forthcoming.

Continued

ARCHES, VAULTS, AND DOMES

The Construction of Arches. Barrel, Groined and Ribbed Vaults. The Construction and Supports for Domes

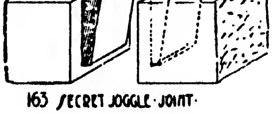
Continued from page 3040

By Professor R. ELSEY SMITH

Arches in Masonry. In masonry walls, openings, where they occur, are, unless covered with a flat stone head or lintel, spanned by some form of arch. The shape that it takes varies with the style of architecture employed; but any form of arch that can be constructed in brick may be equally well constructed in stone. It is not usual, as already pointed out, to form a flat arch in stonework, though this may be done if necessary with stones joggled together, as in the case of terra cotta [page 2780]. In certain styles of architectural treatment, however, an opening covered by a square or very slightly cambered head may have this formed of several stones; but where this is done it is usually for the sake of special architectural effect and not as a constructive necessity, a bold effect being produced by using a large keystone and on each side of it voussoirs not uniform in height but graduated so as to be reduced as the springer is approached [162, page 3039].

Lintels. In most positions where a flat soffit is required, a single stone may be employed for all openings of ordinary width; but it is not desirable to use stones of very great length in comparison with their height, whether used to cover an opening or in the body of a wall, owing to the risk of fracture in case of any settlement; it is generally considered that in stone of a weak character the length should not exceed four times its depth, and in the case of a strong stone the length should not exceed six times its depth when used as a lintel, and where built into a wall the proportion is sometimes restricted to three times the length owing to the difficulty of securing the even bedding of long stones with thin mortar joints.

It may sometimes happen, in the case of a square-headed opening or of an architrave block supported by a row of columns, that stones cannot be obtained of sufficient length to reach between the supports, and where such a support is enriched with a band of horizontal mouldings it is not desirable to cut the face into the form of a voussoir as the joint would then cut all the mouldings at an angle and produce in one of the stones a *feather edge*—that is to say, an angle less than a right angle; in such a case the stone may be worked with a vertical joint on the face and have behind it a very large voussoir-shaped joggle formed [163], which fits into a corresponding sinking in the adjoining stone and forms, in fact, a flat arch, though it does not show as such externally. When this construction is used it must be recollected that a lateral thrust is exerted and a strong abutment is essential.



163 SECRET JOGGLE JOINT

Voussoirs. In arches of stone the blocks of which it is composed are fewer and larger than in the case of a brick arch. They are all dressed for their position and may, therefore, be given the shape of a voussoir quite as easily as that of a parallel-sided block; and this is invariably done, the two sides of the voussoir representing two lines radiating from the centre from which the arch is struck, and a fine mortar joint is employed.

Strength of Arches. The load on the blocks forming an arched structure increases towards the springing of the arch, and in theory the strength of the arch should be gradually increased from the crown towards the springing by increasing the depth of the voussoirs.

Rankine gives the following formula for calculating the depth of the voussoirs. Depth of the crown or keystone

$$= \sqrt{0{\cdot}12 \times \text{radius of arch at crown}}$$

in the case of a single arch, and in the case of a series forming an arcade

$$= \sqrt{0{\cdot}17 \times \text{radius of arch at crown}}.$$

This applies to masonry of the highest class, and for masonry of second quality the depth as thus calculated should be increased by one-eighth and for brickwork and for masonry of poor quality by one-fourth. Where the depth of voussoirs is increased towards the springing the amount of the increase varies from one-fourth to one-half, but for arches of moderate span, including all those used in ordinary building construction, this is not usual, and would not be suitable in the case of work moulded on the face except where the moulding was confined to the lower edge.

The following table gives the usual sizes of stones used in constructing semicircular arches for spans up to 24 ft. of a good class of masonry.

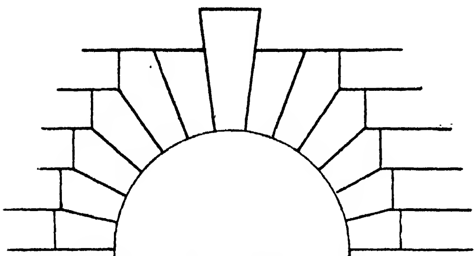
* Span up to	6 ft.	..	9 in.
,, ,,	10 ,,	..	11 ,,
,, ,,	16 ,,	..	14 ,,
,, ,,	18 ,,	..	15 ,,
,, ,,	24 ,,	..	18 ,,

* "Notes on Building Construction"—Rivingtons.

Skewbacks. In the case of all stone arches, except those which spring from a horizontal bed at the level of the centre or centres from which the arch is struck, a skewback must be provided, as in the case of brick arches under similar circumstances; but it is usual in most stone arches to give a much greater rise than is the case with the ordinary brick arch. In any form of rubble wall the skewback is cut in a

single springer or springing block, corresponding with the depth of the arch to be used; this is built into the wall and forms part of the dressings of the openings, and it is not usual to form the skewback in the rough walling as is done in brickwork.

Size of Voussoirs. The voussoirs are not necessarily all of the same width in face, and in Gothic work vary considerably; but for many styles of architecture it is necessary that they should be uniform, especially if the joints are strongly marked. In some forms of arch the voussoir has not a curved extrados, but

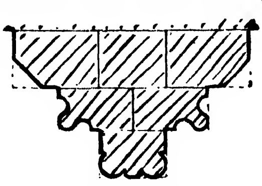


164 ARCH WITH VOUSSOIRS COURSING WITH ASHLAR

is set out so as to present a vertical and horizontal bed, and to bond with the courses of which the wall is built [164].

In many cases the voussoir extends through the whole thickness of the arch from the face to the back of the arch, and this is usual in all buildings of a classical or Renaissance character.

In arches belonging to the Gothic periods, in which the moulded surface is much deeper, a section taken through the arch displays not a single stone; but two or more consecutive rings or orders of stone, each containing a group of mouldings, and these rings are, except in the case of the innermost one, made up frequently of two or more stones in their thickness [165]. In cases where the opening is filled in with tracery, the thickness of the stones forming this corresponds usually with the thickness of the innermost order of the arch, and the tracery itself is built up of separate blocks of stone, some of which are simple, and others complicated, but so arranged and jointed as to form portions of the main or subordinate arches. The joints in each case are formed, as in the case of a simple voussoir, by a line drawn from the centre from which the curve is struck.



165 ORDERS OF A GOTHIC ARCH

Keystones. In many forms of arch, the keystone is given considerable prominence and importance, and is frequently deeper than the other stones of the arch [162, page 3039]. It may stand forward beyond the general face or be carved, or otherwise enriched; this is in no way essential to its structural use, but, being a stone of special importance, it is selected as a fitting object for some special notice and enrichment.

In the case of arches that are pointed in form, as used throughout the Gothic periods, the apex, as a rule, is not formed with a keystone, but with a vertical joint. The arch is not formed of a single simple curve, completed by the keystone, but of portions of two curves which are not complete, and give each other mutual support through their abutting one against the other at the apex. In the same way a single half arch may be made to abut against the vertical face of a wall requiring support, as in the case of a *flying buttress* [168 E].

Vaults in Masonry. Vaulting in masonry has three main divisions—the *plain* or *barrel vault*, the *plain groined vault*, and *ribbed vaulting*, each of which has various subdivisions. The simplest form, that of the barrel, which may be semicircular, pointed or elliptical in section, is in fact an arch with a very wide soffit, and, like an arch, is constructed on a temporary centre [page 2386], but instead of being formed of single voussoirs it is built of courses of stone, each of which is, in cross section, of voussoir shape, and the crown of the arch is formed, not by a single keystone, but by a course of stones forming a key.

Intersecting Vaults. If such a continuous vault be intersected by one or more vaults which run at right angles to the main one, we have introduced at once an element that in some way adds to the difficulty of construction. This is not the place to consider the geometrical forms produced by such intersection, but they will be dealt with elsewhere, and it will suffice to point out here that if the two intersecting vaults are precisely similar in cross section, and spring from the same level, their intersection will produce on plan a line lying in a single plane, but that if there be any difference in the size or form of the two intersecting vaults, the line of intersection will be not a straight line on plan, but a sinuous one. Any such vault is termed a *groined vault*.

The mason will have to determine the exact form this line of intersection will take, and to prepare a series of moulds for those blocks which form the angle between the two adjoining vaults and which will usually vary for every separate stone.

This is particularly complicated when the intersecting arches are noti dentical in section, and it affects the sizes of the stone courses in the two separate vaults [see Drawing for Masons]. The actual working of the stones when their true form has been set out presents no special difficulty, and except at the angle, the stones in successive courses will be similar to the stones in a plain barrel vault. The centres for fixing must be prepared specially to the required form of the groin to be employed [pages 2385–6]. In construction, considerable care is required in forming the groins to see that the individual stones are properly bedded, that they bond with the courses in both vaults, and that the joints are well formed, as much of the strength of the vault depends upon these groins. As a rule, where a groined vault is used, there is no moulding of any kind at the angle, but occasionally a

moulding of slight projection occurs which stands below the general surface of the stone and must of course be kept of uniform width. This is worked on the stone that forms the angle. Notwithstanding the introduction of ribbed vaults during the period of Gothic art, groined vaults continue to be employed for work having certain architectural characteristics, but cannot be applied with the same facility to cover areas that are irregular in plan.

Ribbed Vaults. The ribbed vault was introduced during the early development of Gothic architecture and is structurally a great improvement upon the groined vault [168 F]. Vaulting ribs in the simpler form of vaults consist of stone arches, of which the lower edge may be moulded and the back may be cut to the form of a skewback or rebate to receive the stones of each surface of vaulting lying between two ribs. As in the case of other pointed arches, each half may be considered by itself, and, if the whole system provides proper abutment, it is not essential that the various ribs forming a vault should be exactly opposite to each other. In vaulting a space, the plan of which is irregular, every rib may differ in actual form, and yet all be arranged to extend to the crown of the vault, where it is usual to provide a large central stone against which every rib abuts and which is held in position by their united thrusts.

Use of Stone Bosses. When several ribs abut against such a stone, to avoid the complicated intersection of mouldings that would result it is usual to project the under surface downward below the level of the ribs and to enrich it with carved foliage or figures or both, and to allow the ribs to stop against the edge. Such a stone is generally termed a boss, and is in effect a central abutment common to all the ribs [168 G].

The Vaulting Rib. Each of the individual ribs is, as a rule, a segment of a circle, and the lower end rises from the support from which it springs; in most cases the centre from which the curve of the rib is struck is on the level of the springing, the upper end abutting against the boss. The line of every main rib lies in a true plane between the springing and the boss or apex. The rib or arch is formed of a series of stones formed of voussoirs, but when several ribs spring from the same column, as occurs in many vaults, there is often not room on the capital for the whole depth of each rib to start separately and distinct from each other, especially where they are deep and richly moulded; in this case some of the mouldings in each rib are allowed to die out, the most prominent mouldings only in the lower edge being allowed to run down to the capital [168 G]. The working of these lower blocks is a matter requiring much skill, as it is difficult to prepare bed moulds showing the moulded ribs as they die away, except at the level of the upper and lower beds of each stone.

The preparation of these moulds is complicated by the fact that the beds of the stones for a certain height above the springing are not worked on radial lines, but are horizontal beds, so that the section of the mouldings is not a true section. The height to which these horizontal beds are carried above the capital is not uniform, but depends on the circumstances of each case.

They usually extend to such a height as will admit of each rib becoming completely disengaged from its neighbour. Until this occurs it is almost impossible to provide radiating joints for several ribs of different curvature, when they have all to be worked in a single block of stone. These massive blocks above the capital form an abutment to receive the thrust of the ribs and vault above, and, in planning the vault, it is essential that thrusts on these lower stones from different quarters should practically counterbalance each other, for if this be not so, the stones would be displaced by any excessive thrust from one direction.

Resisting the Thrust of a Vault. It is of equal importance to provide an effective resistance to the whole thrust of a vault composed of a series of ribs with the filling in between them, and which, if erected against a wall or pier at a point high above its base, would tend to thrust it outwards or overturn it. This thrust may be counteracted by the introduction of metal ties holding together the two piers in which the arch rests, so that they cannot spread [168 F]; this, though structurally efficient, is unsightly, and in the finest monuments of the mason's art is never employed.

Failing such a tie, the thrust exerted high up in the wall must be carried down to the level of the ground by a suitably designed mass of masonry known as a *buttress* [168 D and E]. Such a buttress will serve to counteract the tendency exerted by the vault to overturn the wall, either as the result of the total weight of a great mass of material employed or of the skilful disposition of a smaller mass. For further particulars as to the stability of arches and vaults, see MATERIALS AND STRUCTURES [page 2760]. It should be pointed out that the necessity of providing these massive abutments affords the mason a magnificent opportunity of exhibiting the extent to which his art is capable of rendering beautiful and effective structures which in their origin are purely utilitarian; this may be seen by the examination of any good examples of a vaulted building, in which the buttress invariably forms an important element in the external design.

Constructing the Vault. The actual construction of a ribbed vault is a feat of considerably less difficulty than the construction of a groined vault of the same dimensions. The ribs may be first erected as simple moulded arches on ordinary centres, and may be carried up for some little distance without any centring; the groundwork of the vault is thus formed, and the general filling in of the cells between every pair of ribs can be carried out with comparatively slight centring. The ribs are, as already explained, provided with skewbacks or rebates to receive the filling, the surface of which may be adjusted where required to fill exactly the spaces formed by the ribs [168 G]; these surfaces in some cases exhibit a very considerable twist.

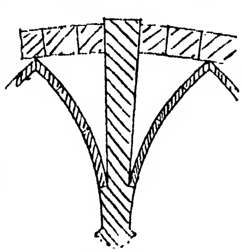
The filling is, where possible, of a light material, as no very great strength is required, and the

upper surface or back is always protected from the weather by an external covering, usually a roof above the level of the crown of the vault. In some old examples of considerable span the filling is not more than 4½ in. thick, and 6 in. is a very usual thickness. Where several ribs rise from a single pier in different directions, a kind of pocket is formed between the main wall and the thin shell formed by the ribs and their filling in. This must be filled in solidly with concrete to a level that varies somewhat in different cases but need not exceed, as a rule, a point on the rib about one-third of the distance from the springing to the crown. The object of this filling is to prevent any tendency of the arch or vault to fail at the haunch by buckling or bending when the vault is completed and the full load comes upon it.

In some of the later Gothic vaults the ribs are very numerous, and when they are formed close together, the filling in between adjacent ribs may consist of a single stone extending from rib to rib for a considerable proportion of the total height.

False Ribs. In the elaborate vaults over small spaces such as occur in chantries, canopies over tombs, and in similar positions, the distinction between the rib and the panel is lost sight of, and the vaulting rib becomes merely a surface enrichment without any structural importance, the vault being formed of large stones carved on the under side into the representation of a ribbed and panelled vault [168 B].

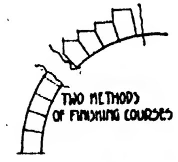
Stone Pendant Vaults. Occasionally, where pendants are employed in vaulting, stonework is submitted to a direct tensile strain. A well-known example is the roof of Henry VII.'s Chapel at Westminster Abbey, in which a considerable proportion of the vault depends for its support on long stone pendants; the upper ends of these are built into the main transverse arch of the vault, the bottom of the stone being several feet below the soffit of the arch, and forming a base from which several vaulting ribs are sprung. This expedient is not very frequently adopted, but if used, care must be taken to see that such stones are perfectly free from any flaws or defects [166].



166 VAULTING PENDANT

Domes. Domes are vaults, circular on plan, and may be constructed like a plain barrel vault, without any break in the surface, and a perfect hemisphere may thus be formed. The oldest existing dome on a large scale is probably the structure at Mycenæ, in Greece, 48 ft. 6 in. in diameter, and not semicircular, but pointed in section. The construction of this, however, differs from that of most domes in that the successive courses are not formed with radiating beds, as in a voussoir, but with nearly or quite horizontal ones.

In ordinary dome construction every course is formed of a ring of stones of uniform height, of which the heading joints all radiate on plan from the centre from which the dome is struck. If a section be taken through the dome at any point, the successive courses will appear exactly as in the case of an arch with radiating joints, forming in effect voussoirs, and each course forms, as it were, when completed, a circular voussoir formed of a ring of stones. The back of each course may be worked to give a stone of uniform thickness, or if the exterior is to have a separate roof covering the top may be formed horizontally, and the back vertically, as is done in some forms of arch [167].



167 · SECTION OF A DOME

Where the section of the dome is that of a semicircle or a segment of a circle, the courses, if equal in height, may be worked from the same section moulds; but should the section of the dome be that of an ellipse, separate moulds must be provided for each course, and, in any case, the face moulds must be varied, owing to the reduction in diameter of every successive course.

Heading Joints. As a rule, in a masonry dome the heading joints in alternate courses are required to be in the same vertical plane, to secure regularity in the appearance of the surface work, just as in the finest ashlar work all heading joints in alternate courses are vertically one above another; but as this would result in the use of very narrow stones in the innermost rings, it is usual to reduce the number of stones and joints in these rings, but those joints that are used correspond with joints in the lower courses.

Construction of Domes. In constructing domes the stones of successive courses have the heading joints joggled together, and the lower courses at least have dowels in the beds of the stones. A centre is necessary during construction, which must be circular on plan, corresponding with the form of the dome.

Such a dome exerts a thrust, which is not like the thrust of a groined vault concentrated at certain well defined points, but exerts an outward pressure throughout the circumference, and must be effectively resisted if the structure is to be stable.

Various methods for resisting this thrust have been adopted, and the joggling of the stones and the dowelling of the successive courses greatly helps towards this end. One method, adopted in the dome of St. Paul's Cathedral as an auxiliary method is to build in at the base of the dome a strong iron chain passing entirely around the circumference; another similar method is to bed a broad but shallow circular iron plate at the base of the dome; but both of these are open to the objection that, should moisture penetrate to the ironwork and corrosion take place, the tie may be a source of danger rather than a benefit.

A heavy mass of masonry boldly projecting internally within the case of the dome has been

168. DOMES, BUTTRESSES, AND VAULTS IN SOME IMPORTANT BUILDINGS

A. Pantheon, Rome (concrete) B. Chapel, Canterbury Cathedral C. Chapel of the Passion, S. Pietro in Montorio, Rome D. Westminster Abbey E. Lincoln Cathedral, Chapter House F. Santa Maria Novella, Florence, Cloister G. Bristol Cathedral, Elder Lady Chapel (Photographs of D and G by S. B. Bolas and Co., 68, Oxford Street, W.)

successfully employed, the weight of the overhanging mass being utilised to counteract the natural thrust of the dome; this method permits of the complete external form of the dome being seen. The base of the dome is in some examples greatly thickened, securing a considerable mass of masonry near the springing, but this conceals the external form. In some cases the base upon which the dome rests is secured by half domes or arches at a lower level, which effectively buttress it. And masses of masonry similar in effect to Gothic buttresses but differing in form are also employed.

Double Domes. For St. Paul's Cathedral, London, the masonry dome visible in the building is surmounted by another dome at a higher level, which in this particular instance is of timber covered with lead, the object being to produce a fine external as well as internal effect, which is rarely possible with a dome of uniform thickness; this system has been employed with variations in several other domes constructed lately.

Ribbed Domes. The internal face of the dome is not necessarily a plain circular vault as already described, but may have ribs formed in its under surface extending upwards from the springing and dividing the interior into compartments. These do not extend, as a rule, to the centre of the dome, where they would become too narrow to be effective, but are stopped by a moulded band at a point some distance below the crown of the dome. This treatment may, in particular, be usefully employed where it is desired to form a central opening near the crown of the dome to admit light by means of a lantern light, the ring of stones which form the opening being of extra depth and serving to stop the moulded ribs.

Coffered Domes. Another method of enriching the inner face is by the use of sunk panels or *coffers*, either between such moulded ribs as have just been described, or as the sole decoration; they form a series of compartments surrounding the dome, of which the upper and lower edges are horizontal and the sides converge somewhat owing to the form of the dome, as a result of which also the width of the coffers in each succeeding row becomes diminished, and the height must be correspondingly reduced. It is also necessary to bear in mind in working such coffers that the moulded sides are not all equally displayed, as in the case of a coffer sunk in a flat soffit, but that while the sides and upper part of the panel are fully seen from below, the lower edge of the panel will cut off from view the inner range of mouldings if they are worked to the same section as the other sides; and it is, therefore, usual to increase the width of each moulding in working it, so that it may be visible as a completely moulded panel from below. The amount of this correction necessarily varies in the different panels, being greatest in the lower ones, the position of which is nearly vertical, and comparatively less in the upper panels, which, as they become approximately horizontal in position, will need no great adjustment.

Methods of Supporting a Dome. A dome must of necessity spring from a circular base, but in many positions it is impossible to carry down such a base to the ground level, and at this stage isolated piers are provided to support the superstructure. These piers may be four, six, eight, or even more in number, but the use of six or of more than eight is rare. If arches are thrown from pier to pier carrying walls a base, square, octagonal, or polygonal, is formed, and it is necessary to convert the form thus arrived at into a circle. In the case of an octagon, the difference between a circular figure and an octagon circumscribed round it is nowhere very great, and the circle may be arrived at by corbelling or a gradual change of the surface. Where a square base, however, supports a circular one, the difference between the two on the diagonal is considerable. One method of dealing with the angle is to throw a series of arches across it, each ring corbelled out beyond the one below, till an octagon is formed, from which the circle is arrived at.

Pendentives. A usual method is to employ the form known as a *pendentive;* this takes the form of a spherical triangle, and occupies the approximately triangular spandrel formed between two arches placed at right angles on plan and the quadrant of a horizontal circle which just touches their crowns [**168** C].

Such a pendentive is, in fact, a small segment of a much larger dome, of which the diameter is equal to the diagonal of the square base, and which is struck from the level of the top of the piers from which the arches spring. This dome is cut into by the planes represented by the inner faces of the four main arches, and the upper part of it is cut off by the plane representing the springing level of the dome; the four portions remaining are the pendentives, each having the general form of a triangle standing apparently on its apex, but having a solid bearing on the pier and at higher levels on the backs of the great arches.

The four pendentives together fill up the angles, and provide a complete circular base on which the dome itself may rest, and its weight is carried by the four main arches by means of the pendentives, though it bears directly on them, only at the crown of each, where the plane of the circular dome touches that of the square base formed by the main arches.

Continued

CYCLOPÆDIA OF SHOPKEEPING

GUN AND AMMUNITION DEALERS. Buying, Stocking, and Selling. Shooting Ranges. Storing Explosives. Legal Obligations

HABERDASHERS. A Modest Trade and its Requirements. Shop, Capital, and Stock. Side Lines. Profits and Prospects

GUN AND AMMUNITION DEALERS

The business of a gun and ammunition dealer is one that stands alone in large towns and cities, but the tendency of the trade is towards the man who prosecutes this department merely as a side line. It is particularly suitable for exploitation by ironmongers, and, indeed, about three-quarters of the guns and ammunition sold in Great Britain reach users through the intermediary of the ironmongery trade. For this reason, our consideration of the department will be upon the supposition that an established retailer wishes to embark in the selling of guns and ammunition, and is willing to spend £100 upon stock.

Personal Qualities. Customers are drawn from the ranks of sportsmen, and success is most promising to the man who is himself a sportsman. In such a position the shopkeeper meets his customers on common ground. His advice is asked and often taken, also he can usually sell better goods bearing higher specific profits if he be himself a good shot.

Guns. The chief disbursement of the £100 allocated for stock would be for guns. We suggest the following as a wise opening selection :

	£	s.	d.
Cheap Belgian guns, 12-bore double-barrel hammer guns, say two of each at 25s., 30s., 40s., 50s.	14	10	0
1 Belgian plain hammerless	4	0	0
American single barrel ejector, 2 at 20s.	2	0	0
2 cheap hammer English d.b. guns at 50s.	5	0	0
2 plain hammerless at £5	10	0	0

Guns of English manufacture should be stocked only when "nitro-proved." The slight extra cost means an increased selling price, and the policy is all in the direction of safety.

A small stock of air-guns, chiefly for winter trade, is also desirable. These air-guns would cost from 27s. 6d. per dozen for the Daisy to 10s. 6d. each for the Gem; and, while they can be easily procured at short notice, a small stock of 1 dozen Daisy, 1 small Gem, 1 ordinary Gem, costs about £2; with, say, 10,000 slugs, at 6d. per 1,000, and 6 dozen darts at 4s. 6d. per gross, demanding 7s. 3d. more.

In stocking any of the more expensive air-guns, care should be taken to stock them only in the No. 1 size, and, of course, only stock the slugs and darts in that size.

The Daisy air-gun takes only one size, which is the B.B. shot, although it takes equally the No. 1 darts. B.B. shot is sold in boxes of 1,000, at 4d. per box of 1,000.

Revolvers. Revolvers should not be handled, except when ordered, because of the restrictions imposed by the provisions of the Pistols Bill, which requires all vendors of revolvers to see that the buyer is either (*a*) a gun-licence holder, who must produce the licence for inspection, or (*b*) a householder who wants to use the revolver in his house or curtilage thereof.

A book has to be kept showing the sale of each revolver, with the name of buyer, particulars of his gun-licence, or proof that he is a householder, and such book can be inspected at any time by the authorities.

Before the passage of the Pistols Bill, a good trade was done in all classes of revolvers, which is now practically closed, because of the restrictions thus imposed. The only revolvers which should be entertained at all are the more expensive ones, because they are more likely to appeal to the class of people who are allowed to buy them; but for a country dealer the stocking of these goods should be eschewed.

Cartridges. If a dealer order 25,000 cartridges, he can have his name printed on them and thus get the benefit of the advertisement. He need not take these in one lot; in fact, it would be wiser to take them in two or three lots. These, if loaded in the cheap English unlined case with manufacturer's smokeless powder, would cost him 60s. per 1,000; and if loaded in a metal-lined case, 70s. per 1,000. The purchase of the first instalment of this parcel would absorb £30 to £35.

During the fruiting season quite a demand arises in the fruit districts for a cheap cartridge for bird scaring, and these are generally loaded with a small charge of black powder and shot, and would cost 40s. per 1,000. The charge of shot principally used is No. 8. There is also a demand for a cheap black powder cartridge for rabbits, which could be procured for 50s. per 1,000. This would reduce the £100 by another £7.

All cartridges kept for stock should be 12 bore C.F., as this is the almost universal demand, and should be loaded with 5 and 6 shot, except the bird-scaring cartridges aforementioned. The odd bores of 16, 20, 24, 28, and 410, as well as pin-fires and odd sizes of shot, should be avoided, as the demand is so small that they would not pay to stock and could be supplied from the manufacturers at short notice.

Miniature Rifles. With the present demand for miniature rifle shooting, and with clubs springing up in every district, a certain sum should be allocated for the purchase of materials to fill this demand. Miniature rifles can be bought by the trade at all prices from 8s. to 52s. 6d. each to take the 22 ammunition.

Ammunition for this is also to be considered, and the cost of same is: 22 short loaded black powder, 8s. per 1,000; 22 short loaded smokeless powder, 10s. per 1,000; 22 long loaded black powder, 10s. per 1,000; 22 long loaded smokeless powder, 11s. 6d. per 1,000. If purchased in case lots of 10,000, a reduction of 3d. per 1,000 is allowed. This ammunition is the best because of its low price, and is now universally adopted with miniature rifle clubs.

Accessories. There are, of course, certain small oddments, which are the necessary appendages of the trade, such as cardboard targets, which can be procured, according to size, from 2s. to 6s. per 1,000. Cleaning rods for guns and rifles are quite inexpensive—thus a 12 bore wooden cleaning rod would cost 1s. 6d. each, and a steel rod for the 22 rifle 8d. each.

Such items as gun-cases, cartridge-bags, etc., should not be stocked at first, because they damage or soil easily, and the demand is a small one. All manufacturers have special illustrated lists of these, and they could be sold from such lists without risk.

Precaution for Stockkeeping. Be sure and see that all guns are kept well oiled, and, in the case of rifles and double-barrel guns, are corked at the muzzle. Dirt and grit of any shop can very materially damage the rifling of the barrels or the mechanism of the guns, thus impairing the accuracy and selling value of the rifle, besides running the risk of the damp atmosphere causing rust. Guns once allowed to get rusty lose very materially in their selling value.

Cartridges should be kept in a dry place, free from suspicion of moisture on the one hand, and not overheated on the other. With cartridges which are made of paper tubes, damp tends to swell the tubes and to prevent their entrance into the chamber, and it also detrimentally affects the shooting power of the cartridge. On the other hand, a heated atmosphere tends to develop unduly the violence of nitro powders, and should be avoided.

When displaying guns—and this is the best means of selling them—they should be placed in racks open to view. A very cheap rack can be made with holes cut out to pass the barrels through, the stock resting upon a shelf placed for the purpose.

Testing Range. It is always a very serviceable adjunct to the sale of guns and ammunition if facilities can be afforded whereby the customer can test his purchases on the premises. The providing of these facilities is rather expensive, and can be undertaken only if the trade warrant it. As far as miniature rifles are concerned, the installation is cheap enough. A small target to stand the impact of a 22 cartridge can be got for £2, and may be placed in the back yard. The effective range of most miniature clubs for indoor ranges is 25 yards, but a good illustration could be made of the efficacy of the rifles, etc., on a 10 yards range.

Shooting Gallery. It often pays to install a shooting range where the general public can test and exhibit their skill in marksmanship in return for a humble coin for every attempt. The present time, when endeavours are being made to develop the individual shooting ability of our citizens, is suitable for establishing such ventures, which need be open, say, only in the evenings, and perhaps during holidays. The gallery ought to have targets at 25 yards, but if there be no near competition in the business, a 10 yards range may serve. Half a dozen rifles for service in the gallery may cost anything from 7s. to 84s. each. It is well to give not less than £3 for each, as good weapons may be had at the price, and these will attract good marksmen. The gallery ammunition costs 8s. per 1,000 upwards, but we may allow 20s. for good charges. At a penny each, 1,000 shots yield in gross revenue the sum of 83s. 4d., surely a high enough rate of profit to satisfy the most grasping of retailers. Some galleries charge only a halfpenny per shot, and there is good return for the venture even at this price.

Prices. The question of price maintenance on cartridges is now being threshed out, and it is very likely that 1907 will see some practical results. A satisfactory arrangement was almost reached in the early part of the present year (1906), but fell through because of the action of one of the manufacturers. It is now, however, in course of settlement. This price maintenance is based upon the giving of 25 per cent. profit on selling prices to all dealers in cartridges.

Guns pay well. The list prices of makers and wholesale importers are frequently subject to 50 per cent. trade discount, and occasionally list prices can be secured. Competition or other reasons usually cause a lower rate of profit to be adopted, but prices are seldom lower than a basis which allows a profit of 33⅓ per cent. from selling prices.

The new terms now given by all ammunition manufacturers embrace a special discount for prompt cash, which works out on an order of 25,000 cartridges to a percentage of 10 per cent. on the year, and this 10 per cent., besides meaning an additional profit on his trade, enables him to compete more successfully with his rivals, and also ensures him the good graces of the firm with whom he is doing business.

We have dealt in this article with loaded cartridges because the restrictions now imposed by the Home Office make the loading of cartridges by the shopkeeper inexpedient, and by buying his components he can seldom make up his cartridge at the price of the fully loaded article filled by the manufacturer.

The Explosives Act. It is desirable that the retailer of gunpowder and explosives should make himself familiar with the obligations imposed by the Explosives Act. There are to-day many retailers of experience and standing who are infringing the provisions of the Act through ignorance or misconception. The original Act has been loaded with Orders in Council until it is rather difficult to decide what is exact law upon several points, but at least the following provisions should be observed. The law differentiates between gunpowder and nitro compounds. The

former is a compound made of saltpetre, charcoal, and sulphur. A person wishing to keep gunpowder for sale must register his name, trade, and premises with the local authority, paying a registration fee not exceeding 1s.

This registration entitles the person registered to keep gunpowder by three methods:

1. In a specially constructed detached building or a fireproof safe away from any dwelling-house or thoroughfare. Maximum quantity which may be stored is 200 lb.

2. In a fireproof safe in a shop or dwelling. Maximum quantity, 100 lb.

3. In a box or receptacle capable of being closed so as to prevent access by unauthorised persons. This box or receptacle may be in any shop or dwelling, and may contain up to 50 lb. of gunpowder.

Common blasting powder may be kept under an ordinary gunpowder licence, as its storage is governed by the conditions which pertain to gunpowder. The stock may consist of both common blasting powder and gunpowder if the total quantity does not exceed that allowed by the Act. Safety fuses cannot be kept in addition to gunpowder or blasting powder upon premises registered only for the storage of gunpowder, but safety fuses only may be kept to any amount without registration.

Mixed Explosives. All explosives other than gunpowder and blasting powder are, under the Act, "mixed explosives." The group includes Amberite, E.C., Schultze, Kynoch Smokeless, Cannonite Sporting Ballistite, Walsrode, Empire, Diamond Smokeless—and these may not be stored as gunpowder, whether in bulk or in cartridges. In order to hold stock of these, the retailer must be registered for the sale of "mixed explosives," which he must keep in either of two specified manners. He may use a "substantial" receptacle which may be a safe or a strong box of wood or iron furnished with a lock and key to prevent access by unauthorised persons. But safety cartridges and percussion caps must not be kept in the same receptacle as gunpowder or small arms nitro compounds; they may be kept if separated by a suitable partition, or in another part of the same room, or in another room of the same registered premises. Under these restrictions, the dealer may keep up to 50 lb. of gunpowder and small arms nitro compounds, and a quantity not exceeding 500 lb. of explosive contained in safety cartridges, safety fuses, and percussion caps. Safety fuses may be kept with any other explosive. Detonators and fireworks must be kept apart from each other and from all other explosives.

Should the dealer desire to hold stock of a larger quantity than permitted under the conditions stated, he may provide a special building of stone, brick, concrete, or iron, detached from any dwelling house, and at a safe distance from any public highway, or a strong fireproof safe similarly placed, and in this manner he may store up to 200 lb. of gunpowder and small arms nitro compounds, in addition to not more than 500 lb. of explosives contained in safety cartridges, safety fuses, and percussion caps.

Loading Cartridges. Should the dealer find that his stock of gunpowder and small arms nitro compounds is in excess of that permitted by the Act, he may avoid infringement by converting the excess into safety cartridges. The regulations laid down by the Gunmakers' Association of London should be observed, as they embrace all legal obligations. They are as follow:

In every case where a loading room is to be used, notice to that effect must be given to the local authorities on the form which is lodged for registering the premises.

Under no conditions shall more than 5 lb. of powder or small arms nitro compounds be present in the loading room at one time, and then only if such explosive is to be immediately used for filling cartridges, powder loaded into wadded cartridge-cases not being counted.

The loading room should be as far as possible isolated from all risk of fire or explosion. The floor should be covered with linoleum or other unbroken surface, and in no case should bare boards be exposed, as the joints are liable to harbour spilt grains of powder. There should be no exposed iron on the floor, bench, shelves, or walls, such as iron nail-heads, etc.

No fire is allowed to be in the room while any filling of cartridges is going on, and no artificial light unless it is so screened and placed as not to cause any danger by fire or explosion.

Every precaution should be taken to prevent the introduction into the loading room of grit or dirt, and, with this end in view, the employees should wear, when in the loading room, over their ordinary boots magazine boots or goloshes, or else their ordinary boots should be removed: and they should, where possible, also be provided with such outside clothing or aprons as will effectually cover the ordinary clothes.

The strictest precautions must be taken to prevent the introduction of matches into the loading room.

No work unconnected with the manufacture of cartridges shall be carried on at the same time as the filling of cartridges.

HABERDASHERS

Haberdashery on its retail side is seldom a distinct independent business, but it is a feature of the scheme of this course that consideration should be given to departments. Haberdashery is usually included in the drapery and a few of its allied trades which are studied in other articles. But it is suitable for exploitation as a separate trade by, say, a draper who is advanced in life, and who finds himself out of employment at an age when he cannot get another. We know several men who have done much better for themselves by such a venture than they could have done by taking another situation even had they been able to find one.

Haberdashery comprises all manner of "small wares" connected with the making of garments—needles, pins, bodkins, cottons, tapes, and such things—which are in everyday demand everywhere. The trade or the department is commonly considered a paltry one, as nearly everything sold is of low price; but it requires, perhaps for that reason, greater attention to detail if it is to be successful. The bump of orderliness must be well developed in the haberdasher, else the multitude of small articles of which his stock is composed will become hopelessly confused, and render the prompt service of customers impossible

The Shop. The haberdasher's shop need not—indeed, must not—be in the main thoroughfare, where the rents are very high, else the expense will swallow up the capital in a very short time. As the goods are not bulky, the premises may be small, and should be rented at not more than £40 in a London suburb or £20 in one of the smaller provincial towns. The fittings are for use more than for show, and are inexpensive—a counter (with glass case top if possible), a few nests of drawers, with plenty of trays, divisions, and partitions. The shelves may be put up by the man himself if he can use tools intelligently. No expensive or elaborate window fittings are needed. The goods must be neatly displayed and classed together, but need not be priced. In fact, the sum of £10 spent in preparing the shop for the stock should be sufficient.

Capital and Stock. An adequate stock of haberdashery can be purchased for £50. A "connection" trade must be the object in view, and a well-assorted stock is necessary. Goods that fade quickly or that are of a fancy nature should be avoided as much as possible. There are some standard articles which form the backbone of the trade, and these must be purchased in every variety likely to be demanded. There are some trades in which selling from catalogues is possible, but that we are now considering is not one of them. For instance, needles of every size and variety for both hand-sewing and machine use must be kept, also pins in all their various forms, from the big blanket pin to the small "baby" variety, safety pins, black and white pins, steel pins, jet-headed pins, large fancy hat-pins, and as for hairpins—the name of the different kinds is legion.

In sewing cottons all the good makers must be represented, as customers have their special fancies. Then there are knitting and crochet cottons, mending cottons, and wools in hanks and on cards, threads in black, white, and colours, from the fine to the heavy qualities; thread for carpets and upholstery work, machine and sewing silks of all colours, and twist for buttonholes. The variety of tapes is also large, including white, black, and coloured in all widths both linen and cotton, bindings, beltings, strappings, galloons, webs, cords, dress preservers, and boot and stay laces in silk and cotton.

Dressmakers' sundries will include hooks and eyes, whalebone, springs for dresses, and corset busks. There must be tape measures from the humble penny article to the aristocratic shilling spring measure in a metal case, thimbles in steel, bone, brass, and silver; buckles, waddings in black, white, and colours—the last-named for jewellers' use—cords, elastics, garters, suspenders, glove and boot button-hooks. There is great variety in buttons, which must be kept in linen, cloth, china, pearl, metal, bone, and horn for every possible kind of garment in all colours and styles. We have enumerated the classes of haberdashery which may be bought for the £50 note we assumed to be at the disposal of the opening shopkeeper. These may be considered the essentials of the stock.

Side Lines. There are other things which should be added at the beginning, if funds permit. The list of extras includes trimmings and gimps for ladies' dresses and mantles, girdles, buckles and clasps, belts, braids, fringes, black and coloured beads, jet trimmings, useful yarns, such as Scotch yarns, Berlin and Shetland wool, Andalusian fingering. Tailors' trimmings should also be included as soon as possible. They will comprise cotton, silk, and wool linings, Italian cloth, buckram, buttons, twists, chalk, and all the little accessories needed by the tailor.

By studying to make the stock complete and to avoid the likelihood of being asked for anything which he cannot supply, the haberdasher will acquire the reputation of keeping "the handy shop," and he will be resorted to as a matter of course, with the confidence that he will be able to supply at once what is wanted.

Yet there are a few things which it will be well to avoid keeping—coloured ribbons, for instance, which involve a heavy outlay and result in loss by soiling unless their sale be very large.

Certain articles of cutlery pertinent to the haberdashery trade are worth keeping, as they are exceptionally remunerative—scissors for embroidery, buttonholes, and for dressmakers' and household use, tailors' shears, pocket knives, stilettos, and nail-files.

Sewing Machines and Fancy Goods. A sewing machine might be bought and held for sale. The class of customers who come to the counter are those who use sewing machines, and an odd machine can be sold now and again. The profit on each machine need never be less than a sovereign. If the sewing machine trade be attempted, there will be a demand to sell the machines on the instalment system; but, unless the retailer knows the customer to be absolutely exact in meeting obligations, he will resist blandishments to induce him to part with goods on such terms.

Some fancy goods offer opportunities, especially about Christmas time—such things as needle and cotton cases, cabinets of haberdashery assortments in wood and leather, to sell at from 1s. to 10s. 6d., ladies' companions, and not forgetting the "bachelor's roll" containing an assortment of buttons and thread, needles and pins, and selling at about 2s.

Profits. The profits will not be less than 20 per cent. of the selling price, and on fancy articles such as scissors, thimbles, needle-cases, not less than 33⅓ per cent. Most of the selling will be for cash, as the money is taken in small amounts; but it will be well to have a few monthly accounts with tailors and dressmakers, who will probably appreciate the convenience by becoming steady and regular customers. As the goods of a haberdasher do not get out of fashion or soil easily, there is practically no loss from unsaleable or soiled stock such as is found in the general drapery trade.

Continued

TEXTILE ORNAMENT

Weaving Figures and Ornaments. Diaper and Damask. Gauze and Lace. Velvet and Velveteen. Chenille

Continued from page 2944

By W. S. MURPHY

THANKS to the great art spirits of the nineteenth century, the textile designer has been freed from the bonds of convention. Our designs are not now the futile imitations of foreign forms, made conventional beyond recognition, which were imposed upon our predecessors of the early Victorian era. The designer may go out into the fields, and, in loving communion with Nature, derive fresh ideas and new forms. He can bring from the roadside the beauty of familiar flowers ; from the harvest field the golden tresses of the barley, the rich fulness of the wheat, the waving crown of the ripened oat ; from the woodland visions of green and tinted traceries against the shadowy verdure of the grass or the azure light of the sky. These, his treasures, he can freely display on the cloth designs he makes for the weaver and the wearer. Allowing free play to his imagination, he must also discipline it with the sense of fitness.

The latitude given to the cloth designer may be nobly used or grossly abused. There are two directions which wrong practice has taken. One is the sacrifice of sound structure to ornament ; the other is a false sensationalism, presenting objects with a pretence at reality altogether false and grossly vulgar. We can confidently say, however, that at no time in the history of British industry was there so much good art and sound design in textiles as there is at the present day.

136. DIAPER

Ground Warp and Weft Figures. Making figures is so easy that we feel tempted to enter lightly on the venture. Take a plain cloth, for example. What is easier than to make the weft skip over the warp here and there, or in regular gradation, to form a design or figure on the surface of the cloth ? It is easy, very easy, and we would doubtless produce very pretty figures ; but the result would perhaps astonish us sorely. At the end of a yard we might find our warp pulled tight here and lying slack there, and the figures all staggering drunkenly across the cloth. Inquiring into the causes, we would find that the very foundation principles of textile production had been violated. Structure is the alpha and omega of weaving. We observed how every pick of weft in plain cloth takes up a certain length of warp. If any warp thread is missed by the weft, it must become slack, because what it gives out with the rest is not taken up. When one warp and one weft are used, the balance must be maintained in some way. If, at this point, the weft floats over seven warp threads at this pick, six of the same section next pick, four at the next, the slackness on the four of the missed three picks, and on the other two of the picks missed, must be made up in another place, or the balance of the web is destroyed. We may repeat all over the fabric, at close intervals, the small figure, and so restore the balance before any harm is done ; but while the relation of warp and weft may thus be put right, the pattern may present a very broken and absurd appearance. We can say, however, that a simple and modest design, which is worked in accordance with what may be called the law of textile structure, is always more pleasing to the eye than any form of pattern which does not come within the law.

Practical Rules. In general, the designer should lay down a plan of the proposed figure, or combination of figures, and find out what intersection of warp and weft is needed to form the pattern. When this has been done, the practicability, or otherwise, of the design will at once appear.

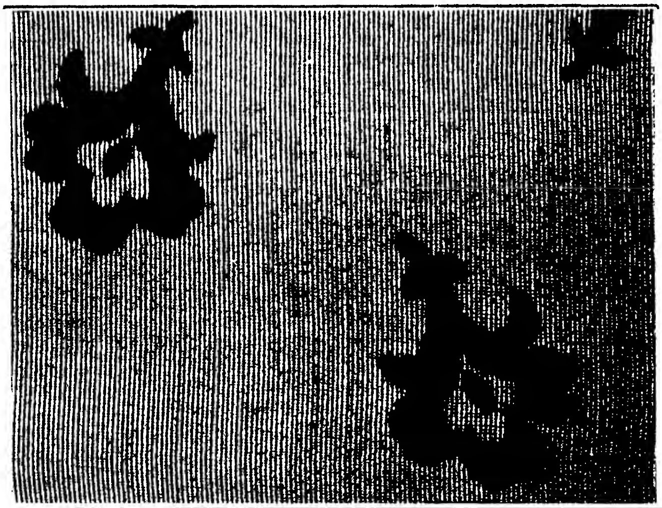
Common twills and broken or satin twills are often ornamented with good effect. In fact, the comparative looseness of the fabric lends itself to aid in the formation of figures. Selected with judgment, very slight changes on the twills produce fine effects, especially in forming natural figures in conventionalised forms, definitely suggesting without attempting too much.

Using the ground warp or weft, or both, it is possible to make figured cloths of a highly artistic and useful character. Small mathematical figures, spots, stripes, checks, floral designs, scrolls and flourishes can be carried out on the material of the fabric. One limit applies to all designs, if the fabric is not purely ornamental—the design must not occupy so many threads as to weaken the body of the cloth.

Diaper and Damask. Those fine fabrics are figured on a simple principle, the explanation of which need not take long, though the practical working of the designs should be carefully considered. Diapers are simple twills [136], the pattern being formed by the change from warp to weft on either surface. Suppose it is desired to form a four-end twill on an eight-end pattern. On the first eight ends the weft comes to the surface ; on the second eight ends the warp forms the twill. It is as if we had turned over the web, bringing the back to the front in a magical fashion. The twill runs the opposite way when formed by the warp from that when formed by the weft. The simple change in the direction of the twill,

added to the different direction of the predominating threads, alters the aspect of the pattern to such a degree that the average unskilled observer would refuse to accept the statement that the two squares are merely reversals of one twill. Working on this principle, we can produce a large variety of patterns.

Styles of Diapers. On the diapers of the middle of the nineteenth century the figures are mostly on the mathematical plan; but during the past twenty years the difference between diapers and damasks has almost disappeared. It used to be said that a true diaper was in squares or sections of squares, and damask was floral or figured; but now you will find more diapers in floral designs than any other form of pattern. Instead of a simple twill, therefore, we have often a satin or broken twill, this form of twill obviously lending itself more readily to the formation of large and varied figures. By making the figures with a simple change from weft to warp on the surface, we avoid one danger of figuring with single warp and weft, *viz.*, the weakening of the fabric by the predominance of floating threads. The other trouble which arises from the irregular interweaving of warp and weft is never wholly overcome, however, except in specially happy combinations. Fine fabrics do not show the defect so obviously as heavy cloths; but close examination reveals the fact that the interweaving at the point of change is imperfectly covered.



137. SWIVEL CLOTH

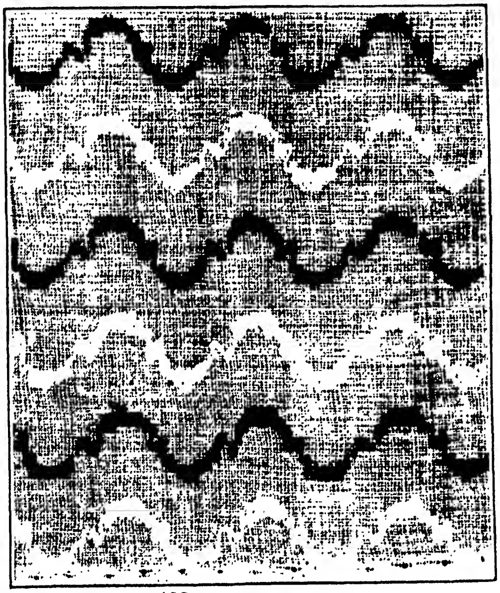
Extra Warps and Wefts. Advancing from the simple to the complex, we now come to consider a class of fabrics which it is the ambition of every young designer to handle. Long before we have mastered the rudiments of cloth structure, we dream of the varied and rich patterns we could make if only we had liberty to work with extra yarns. In its proper place, such an ambition is far from reprehensible; its proper place, however, is dreamland for a year or two. Excepting in special forms, which must be studied in detail, the principle of making double-faced cloths is applied to the use of extra yarns for figuring and ornament. Sometimes we use only extra warp, sometimes only extra weft, and in some instances added warp and weft. In a large number of those cloths, the extra yarn plays no part in the structure of the cloth. The sole concern of the designer, in such cases, is to obtain a proper passage for his extra material, and a strong binding. These two things are not always easily obtained, especially if the intervals between the figures formed by the extra yarn is considerable. Where it is possible to use soft, thick threads, the difficulty of getting a clear passage is evaded, but the problem of safe binding is rather intensified.

Binding Figures. If the ground cloth be light, we cannot carry the thick threads of the figuring yarns along with it; and if we cut, we have little beyond the binding threads at the points of intersection to hold the yarn. This is not sufficient, in most cases, and some other plan is generally adopted, such as using the binding edge as shading of the figure, or some other expedient of a like nature to give the figuring yarn a hold in the structure of the cloth. With liberty to use as many colours as we need, and to pile, say, three or four yarns on top of each other, should the design so require, we enter on the freedom of the artist. But warp and weft impose limitations which can be evaded only by the art which conceals art. Stripes, spots, checks, rows of figures, straight lines of flower or foliage, curves that give a regular gradation of intersection between the woven threads, should be attempted first. An exacting market makes higher and ever higher demands upon the designer's craft and ingenuity; but it is only after we have thoroughly mastered the simpler forms of design that we can hope successfully to venture on those combinations which bring weaving up to the level of the plastic arts. Learn to use extra warp, extra weft, then both; next combine the ground with the extra yarns, and, having done all this, the higher possibilities of textile design will be well within reach.

Swivels. Without a knowledge of the structure of the loom, this class of design can hardly be fully understood; but we must presuppose a certain general understanding of the weaving machine, and in a short time expect to study the loom in every detail. We have judged it better to develop our theories before considering the applications of them, which are many. In weaving cloth we have the warp and

the shuttle, the latter bearing the weft into the warp and crossing from side to side. The swivel is an apparatus holding as many small shuttles as there are figures in the breadth of the web, the weft from each shuttle forming only one figure [137]. This is a method of forming figures with extra weft, which is coming more and more into use. The crossing shuttle waits, and the warp is held while the little shuttles perform their work. By this device weft is saved, and there is no need to cut away the floating threads between one figure and another. Anxiety as to binding is also spared. Many highly ingenious applications of the swivel have been invented, but the secrets of these are jealously guarded by the firms using them. Many patterns which seem textile impossibilities are done by the swivel.

Lappets. Employed for a similar purpose, lappet weaving is the opposite of swivel weaving. Instead of extra weft we have, in lappet, extra warp, used in a peculiar way. This extra warp may come from a second beam, or a creel of cops set below the loom. The threads are led through needles set upright on a horizontal bar which has two movements. It moves up so as to bring the threads it carries to the level of the warp as the shuttle brings the weft across; and it moves to and fro in obedience to the guiding finger inserted in a wooden dial at the side of the loom. The first movement is to get the benefit of the binding weft; the second movement is to form the figure on the warp, the curves on the dial being turned in the manner necessary for the formation of the figure [138]. As the lappet apparatus moves on the under side of the warp, the web is woven wrong side up. The dial being movable, the positions of the lappet threads may be altered in any way the designer desires. This enables him to avoid the stiffness of line and straight regularity which are the great obstacles to artistic textile work. Lappet weaving has its obvious limits; the threads must always present a flat surface, which tends to give a conventional appearance to the figures. But the variety of colour and figure this method of weaving affords makes it worthy of keen study and frequent application.



138. LAPPET CLOTH

Various Fancy Cloths. The old handloom weavers were probably as intelligent a class of craftsmen as the world has known. Even before the power loom was invented, the weaver had made his machine an instrument capable of performing operations far more complex than the mere plaiting of warp with weft. As a result, forms of cloth have been handed down to us which call for both ingenuity and artistic skill. In our present course we can glance at but a few of the various fancy cloths evolved by the weaving craft.

Crinkled Cloths. Every now and again there arises a demand for cloths which have a drawn, or crinkled appearance, and the demand is met. If you pull a warp thread out of a piece of cloth, you will observe that it crinkles up; held with moderate firmness, the crinkles form regularly. Apply the principle to weaving. Having determined the measure of crease or crinkle required, and the breadth between one ridge and the next, you fix behind the reed of the loom a series of nippers, or catches, which grip on to the selected warp threads. These threads are momentarily held while all the rest go forward with the movement of the loom. The combined slackness and tightness thus created form the cloth into regular crinkles, which are ineradicable and integral in the body of the fabric. The cloth can be no longer than the shortest warp threads, and the warp and weft which have gone forward must curl up to keep alongside the shorter length of the restrained warp. Many very pretty effects are achieved by this simple device.

Flounces or Tucks. A common application of the crinkling method is the formation of tucks or flounces by weaving. In this case, however, the cloth is double, and two warps are employed. The double cloth is woven to form the basis of the fabric. At the moment when the tuck is to be woven the one warp is withdrawn, and a single cloth is made the breadth necessary for the tuck. When this has been done, the other warp, which has not moved an inch, comes into play again. The slack is made up by the folding together of the cloth, which is secured by the resumption of the weaving of the whole fabric.

Fancy Warps and Wefts. Variations in colour of warp and weft we take as a matter of course; but designers have called into use another device, which, when properly applied, is singularly effective. Fancy forms of yarn, such as knopps, curled twists, and loop-threads, vary the surfaces of cloths without making any special demand upon the loom. It is safer to use these yarns as warp because we have more

certainty of placing them rightly. Cheap forms of imitation astrakhan and other imitation furs can be produced in this way, besides many fancy dress cloths.

Special Fabrics. There are some fabrics which owe their existence wholly to the love of mankind for decoration. In southern countries, and during the warm summers of temperate climes, clothing is worn by civilised nations less for physical comfort than for social respectability and the pleasure of wearing fine clothes. Therefore, the weavers very early devised a class of fabrics which combine lightness with strength, and which may be easily ornamented. Among these we find a large range of light cloths, which are technically classed as *gauzes*.

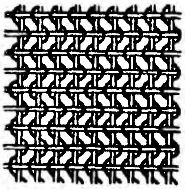
On the other hand, there is a class of cloths which have been from time immemorial dedicated to ceremonial uses, or for giving a rich appearance to the persons by whom they are worn. These are what we call *pile cloths*, including in the class velvets, velveteens, and plushes. Velvet is the stuff of which the regal robes of kings and princes are made; it enters into the structure of the crown of the monarch and the coronets of dukes and peers. Because of its peculiar structure, velvet is the richest of all fabrics, the heaviest, and yet the most easily draped. Composed of short threads of silk standing up from the ground of the cloth, closer and finer than the finest fur, velvet is the costliest and strongest of silk fabrics. It is used for hangings and draperies by persons of wealth, and the designer gets many an opportunity of exercising on velvets his highest artistic powers.

Plush is the cotton imitation of velvet, and serves many useful as well as ornamental purposes. For hangings of a temporary nature, this material serves just as well as velvet. Figured and stamped plush is greatly used in the making of cheap picture frames, the upholstery of furniture, and other purposes of that nature.

Velveteen is also a cotton velvet; but it has a character and position of its own. In structure, as we shall show, the cheaper cloth differs considerably from velvet. It is the true fustian, the cotton cloth which was the favourite wear of millions of the working people during the early part of the nineteenth century, and originally demonstrated that cotton could be made into a strong and substantial cloth. The pile of new velveteen possesses a sheen which rivals in lustre the cheaper classes of silk velvets. It fades soon, of course; but the fabric is undoubtedly very pleasing and of great strength.

Gauze. In the fabrics we have already studied, the main structure has been composed by crossing weft and stretched warp; but when we come to gauze a different stage in textile development is entered. Warp is the passive factor in the formation of plain cloths, but it takes an active part in the construction of gauze. Lappet weaving has prepared the way, in a measure, for the active warp; but the action of gauze warp is strongly significant, for all that. The whole loom has become active. To make plain gauze, we divide the warp thread into pairs, and gear, or mount, the loom so that each pair of warp threads will cross, the one over the other, each thread passing from right to left, and up and down alternately [139]. It must be taken for granted, of course, that two parallel threads cannot twine round each other; they can only change positions, and perform half a circle each. Two threads acting on each other in that way would be futile, and produce nothing; but the coming of the weft thread between them at the moment of crossing makes all the difference. When the crossing thread wants to get back to its former position, it finds the weft between it and the crossed thread, forming a little knot. The next pick of weft comes along and is brought as closely up to its neighbour as possible; but the thickness of the two warp threads intervenes, and the weft threads must lie apart. This is the essential nature of gauze, it is practically a kind of miniature netting [140]. With a fabric so firmly bound, so strong, and so open in texture, variation and ornament suggest themselves. The first step is to find out how many good and firm gauzes we can produce by varying the crossing of the threads. Reversing the cross of every alternate pair, we obtain a result not unlike a diaper effect; carrying out the idea further, very pretty figuring may be done by simply altering the orders of crossings. Alternate thick and thin warp or thick and thin weft produce quite admirable effects. Changing the order of weaving, weaving a different number of picks in selected crossings, and other similar and simple devices, give variety to gauzes, and also prettiness at small cost.

139. SECTION OF GAUZE



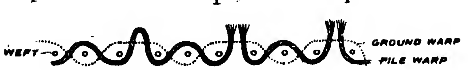
140. DIAGRAM OF GAUZE

Gauze and Lace. It has been said, with a certain degree of truth, and an equal measure of severity, that you can do anything with gauze except make it into a good cloth. All the devices of ornament can be utilised on gauze—extra warp, extra weft, swivel, lappet, knopp, and curl yarns, and in addition, we can introduce plain cloth. The highest achievements of the gauze loom have been in the direction of producing elaborate lace fabrics. For a time, the cheap production of the lace looms seemed to drive the gauze weaver out of that market; but the tide has turned the other way, and the gauze weaver threatens seriously to retaliate upon the rival trade. Lace insertions, narrow laces for trimmings, lace handkerchiefs, table-centres, fancy covers of all kinds, figurings the most delicate, are now produced on the gauze loom. But all this is matter for experiment; any length of discoursing would not help the student. In such a case, the tutor ought simply to give a few practical hints, show what can be accomplished, and leave the

rest to the intelligence, energy, and practical experiment of the student.

Lace. The lace designer has models by the thousand. We speak of the machine-lace designer, of course. From before the Christian era down to the present hour the ingenious minds, vivid fancies and nimble fingers of leisured ladies, religious devotees, and industrious housewives have been constantly developing new forms of lace. Lace designers, therefore, are more often required to find out how to weave a certain pattern than to invent new forms of lace. Bobbin-net is the simplest form of lace, and affords easy lessons for the beginner. He has to regard the warp threads as straight vertical lines, round which the weft threads, which have a limited area of crossing motion, but a constant power of twining from warp thread to warp thread, must be twisted in such order as to form the pattern. Lace warp is vertical, and not horizontal as in the weaving loom. The weft does not shoot across the web, but passes between one pair of warp threads and comes back between another pair at such nearness of distance as may be designed. By this twining the net is formed. In ordinary bobbin-net the warp threads are passive, the bobbins doing all the work. But, suppose we give the warp threads mobility, complicate the actions of the bobbins, and add appliances for directing both warp and weft in special ways, what then? We shall, at any rate, possess a real lace loom, and one capable of being used for the reproduction of very complex designs. It is obvious that with such a machine fabrics of a light, open texture may be produced in vast variety. Before concluding our studies we shall devote considerable attention to lace-making by itself.

Velvets. Velvet is the most beautiful of all the pile fabrics. By a pile fabric we mean one the surface of which is formed by warp or weft raised above the ground of the fabric. As commonly understood the term velvet is only applied to the pile cloth formed by silk warp. We say that velvet is formed by the piling, or looping up, of a silk warp, but the question comes, How is it done? Velvet is composed of two warps, one the pile and the



141. SECTION OF VELVET

other the ground [141]. The loops are formed by passing wires across the web, so that the silk warp must weave them in with itself. Before passing over the wire, the pile warp goes under a weft thread; and, after coming over the wire, is again bound down by a weft pick. But the ground fabric must also be taken into account. One ground warp thread comes up over the weft thread, and accompanies the silk, excepting that it passes under instead of going over the wire. At the second pick, however, this warp thread binds over the weft thread, and passes under the next. Thus the silk is bound closely into the ground fabric and supported by it. The highest class of velvets are cut by hand with a guide knife, which we shall see when we come to look at the velveteens; but the great mass of the fabric is cut by a small blade at the end of the looping wire. To ornament this precious cloth has always been the ambition of the artist designer. One method much favoured is the alternation, or varied distribution, of cut and uncut pile. Velvet and "Terry," as this combination is called, produces very pretty effects. Another method is the introduction of extra silk or silver or gold threads for figuring. If this be well done, no more magnificent fabrics could be imagined. The last which calls for special mention is the figuring by means of vari-coloured velvets. To do this successfully we must stain every thread in sections so that the point of each cut thread will show exactly the colour needed in the figure.

Velveteens. Cotton velvet, or velveteen, is a fabric which has many uses. Instead of the pile being formed by the warp, as in velvet, a floating weft makes the loops which are afterwards cut into pile [142]. While velvet might remain with loops uncut, velveteens must always be cut. An imperative necessity arises in the latter case for the floating threads forming the pile being well bound in the structure of the fabric.

142. SECTION OF VELVETEEN

If not strongly secured the pile will readily come away from the cloth and render all our labour useless. This problem has exercised the minds of many experienced designers. There are many things to be taken into account. For example, the number of floating weft threads we weave together depends wholly upon the quality of cloth we have to make. Similarly, the length of float, whether over five, six, or seven warp ends, depends on the length of pile desired. These conditions materially determine the pattern to be adopted for binding the floating weft threads. One good rule may be given. The weaving of the ground weft threads should always be contrary in interweaving with the warp at the point where they bind into the warp.

Chenille. This is a peculiar kind of plush, or velvet; it can hardly be called a cloth. Chenille is largely used in fringes of various kinds, But it derives an added importance from the fact that it forms the weft of the Patent Axminster carpet. Weft and warp may be of wholly different fibres; in the case mentioned the weft is worsted and the warp is linen or flax. In the best chenilles the warp is set gauze fashion, but in groups of threads separated by exactly double the length of the fringe we propose to make. The weft is woven in the ordinary way, floating between the warp threads, but otherwise interweaving with the warp in common gauze style. When the web is completed, the "cloth," if we may give it the name, is shorn through to the centre of every floating section of weft. The product is firmly bound fringes, which may be twisted for various purposes or kept plain for use in the carpet loom.

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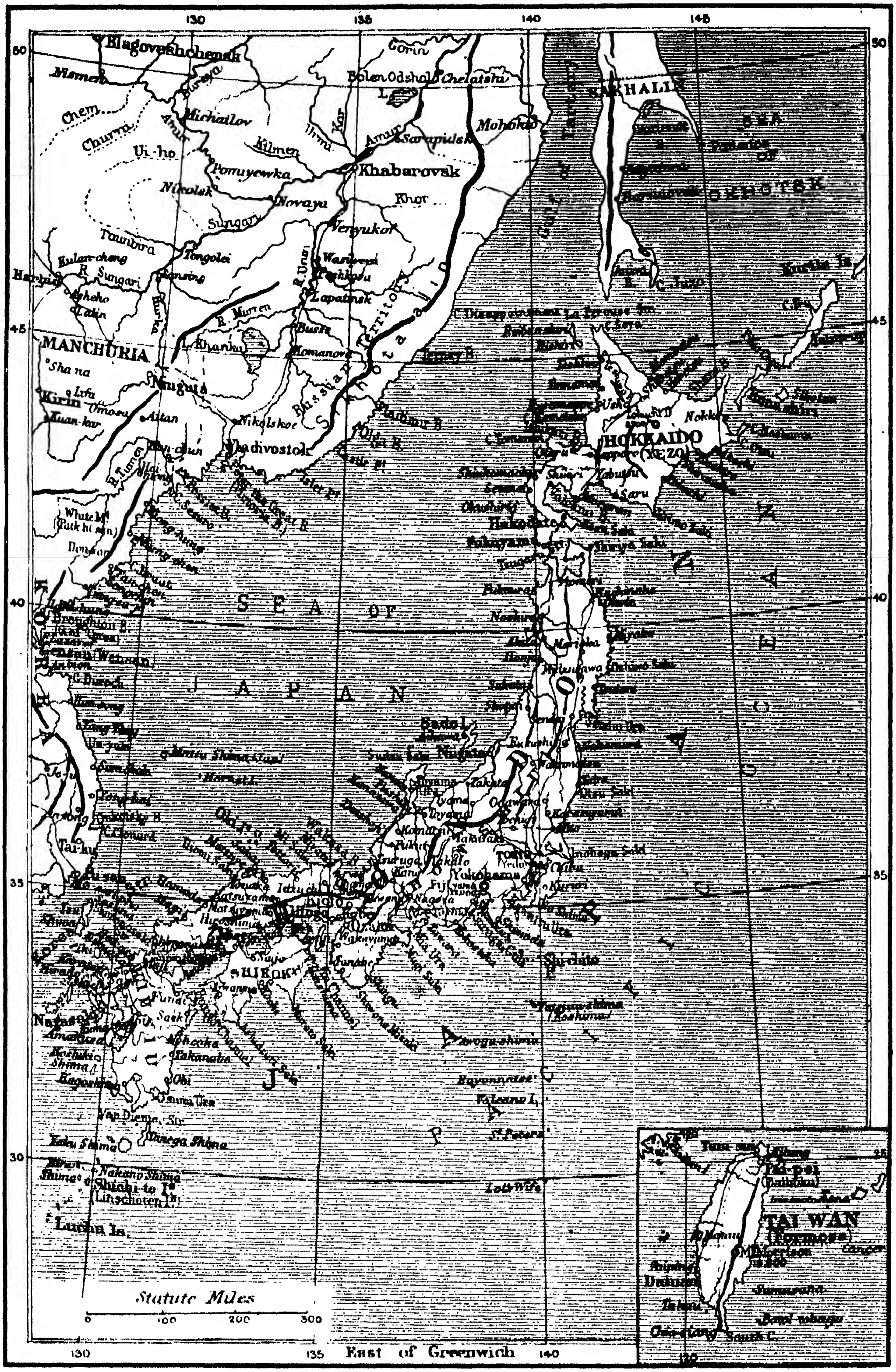


120. THE JAPANESE EMPIRE

THE JAPANESE EMPIRE

Japanese Islands. Build of the Country. Fujiyama. Successful Agriculture. Fisheries, Minerals, and Manufactures. Malay Archipelago

Continued from page 3077

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

The Japanese Empire. The Japanese Empire (161,000 sq. miles) consists of five large and 600 small islands, forming a double festoon from Kamchatka to Southern China. The chief groups and islands are (1) the barren Kurile Islands; (2) Hokkaido or Yezo, the most northerly of the larger islands, separated by a narrow strait from (3) Hondo or Honshiu, the largest island, off which lie (4) Shikoku and (5) Kiushiu; while (6) the long Luchu group connects the islands named, which form Japan proper, with (7) Formosa, taken from China in 1895. The southern half of Sakhalin was added to Japan in 1905.

The Japanese Empire stretches from the latitude of Northern France to south of the Tropic of Cancer, and varies in climate from temperate to tropical, modified somewhat by oceanic conditions. All the larger islands lie in the monsoon area, and have abundant rains.

Japan. Japan proper is everywhere mountainous, and large plains are rare. The island lies on one of the great world lines of volcanic activity, and volcanoes, active and extinct, are numerous. Of many extinct cones, the most perfect is Fujiyama, the sacred mountain of Japan (12,000 ft.). Owing to the abundant rainfall, dense forests cover three-fifths of the area. With the world's demand for timber rapidly increasing, as the supply decreases, this is a valuable national asset, and the Japanese wisely pay great attention to scientific forestry. The rivers are numerous, but short. Though too swift for navigation, they serve to float down timber, to irrigate the cultivated lowlands, and to generate power.

Among the forest trees are the sago plant and bamboo, both found as far north as Tokio, the lacquer tree, the camphor laurel, etc. Familiar trees are the pine, elm, chestnut, and beech. A beautiful tree is the cryptomeria, a stately cedar. Flowering shrubs are everywhere, for Japan, even more than China, is a flowery land.

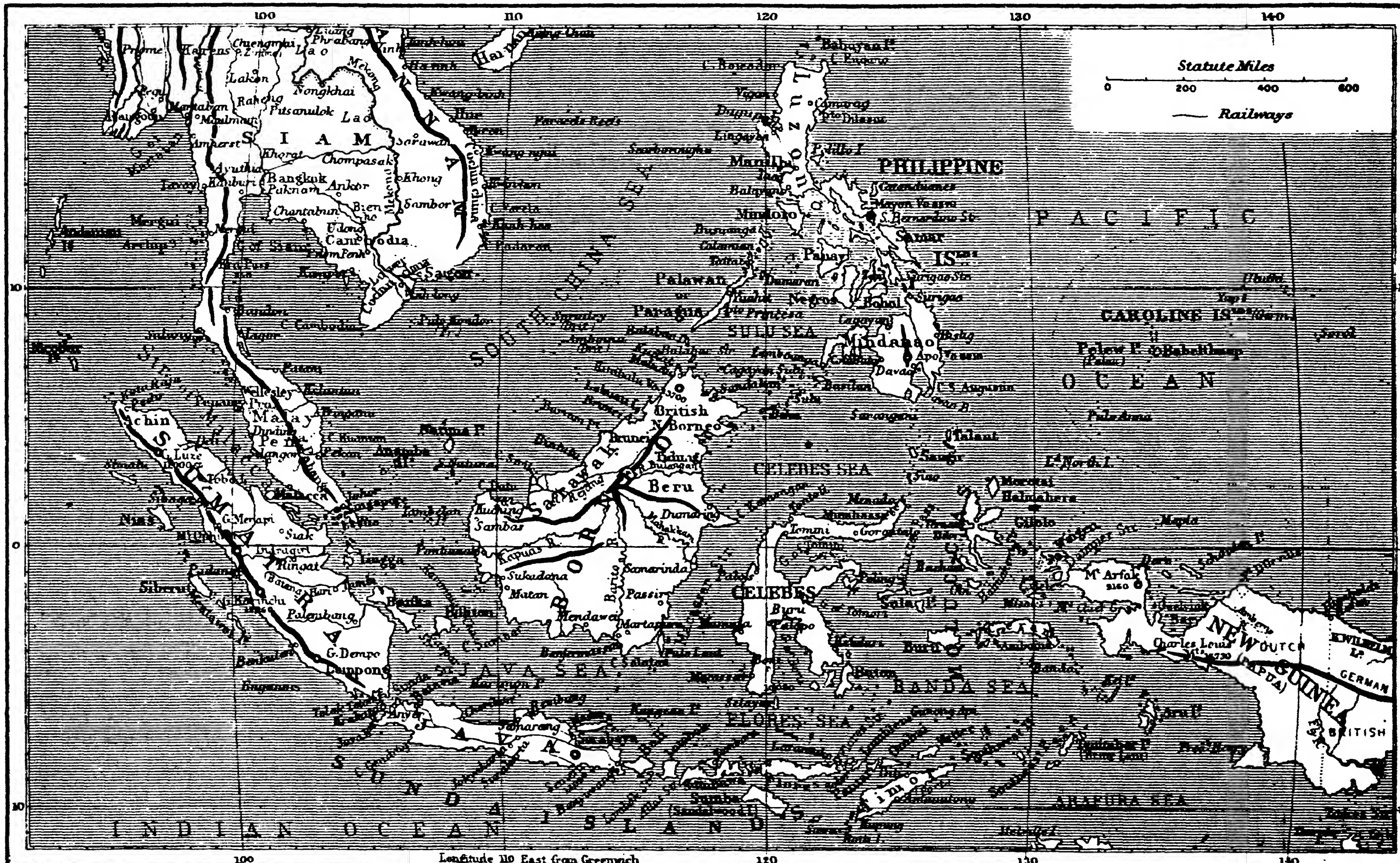
Fujiyama. No one can think of Japan without thinking of Fujiyama, or Fujisan, which figures in every Japanese picture. "Living at Tokio," wrote Sir Edwin Arnold, "or Yokohama, or anywhere along the Tokaido, the southern road of Japan, you would soon see how the great volcano dominates the landscape and becomes an indisputable element in the national scenery. Far away at sea, when approaching Japan, long before the faintest blue line of coast is discernible, there is seen hanging in the air a great white symmetrical cone. That is Fuji. After you have landed, you will always be seeing Fuji from some garden, some tea-house gallery, some grove of cryptomeria, or thicket of bamboo. There are loftier peaks, of course, but there is none which rises so proudly alone from the very brink of the sea.

"It is a circuit of 120 miles to go all round the base. The lower portion is cultivated to a height of 1,500 ft., and it is a whole province which thus climbs round her. From the border of the farms begins a rough and wild but flowery woodland, which stretches to 4,000 ft., where the thick forest belt commences. Above the forest extends a narrow zone of dwarfed larch and juniper, after which comes the bare, burnt, and terribly majestic peak itself." In winter the snows extend half down the mountain's colossal sides, adding the last touch to its beauty.

Japanese Agriculture. The lowlands of Japan are only one-fourth of its area, and only one-sixth of the islands is cultivated. Nevertheless, the population is very dense, and agriculture is the chief occupation. Many causes account for its success. The first is the laborious industry of the people, who practise spade cultivation and till their farms with the care of gardeners. Secondly, no fertilising matter is wasted in sewage, so that manure is abundant. The third cause is the prolific nature of the staple crop—rice. All rice lands are densely peopled. The fourth cause is the frugal habits of the people, who can subsist on a scanty diet of rice and fish. These causes have hitherto enabled Japan to support her large population at home; but the pressure is now beginning to be felt, and the Japanese, like the Chinese, seem destined to colonise extensively around the shores of the Pacific. Owing to the value of land for agriculture, livestock has never been important in Japan, though horses are now being bred for military purposes.

Japanese Crops. Rice is the staple cereal, with wheat as a winter crop. Barley and beans are largely grown. Most farmers breed silkworms. Mulberries are planted in rows between the crops, to which they give shade. Tea is the second staple. It grows well south of Tokio, and is found wild on the hills of Kiushiu, Shikoku, and Formosa. Native cotton is very short in fibre; American cotton has been introduced, but the demand of the cotton mills is not yet met. Tobacco is a Government monopoly. Fruit is grown for export; the cherry and plum have been planted from time immemorial for the beauty of their blossoms.

Fisheries. The seas around Japan swarm with fish, and the shores are everywhere indented with good harbours, while the wooded hills surrounding them provide timber for boat building. Nearly 1,000,000 families are employed in fishing, and fish is a staple of Japanese diet.



121. THE MALAY ARCHIPELAGO

Minerals and Manufactures. Coal is found chiefly in Hokkaido and Kiushiu. Iron is abundant, but is not found near coal. Petroleum is widely distributed, and Japanese copper is of very fine quality. The arts of Old Japan were no less exquisite than those of India, including wonderful lacquer work, porcelain, cloisonné, and other decorative metal industries, painting and embroidery. Within the last fifty years the industries of the west have developed rapidly. The hideous mill chimney is now a common sight in the exquisite Japanese landscape. With their frugal needs and extraordinary technical skill, the Japanese will soon become powerful rivals in the markets of the world. Ozaka, on the Inland Sea, is the Manchester of Japan.

Japanese Towns. Hakodate, in Hokkaido, near rich coalfields, is the outlet for the resources of that island. In Honshiu, the capital is Tokio, with many industries, including shipbuilding and chemical and engineering works. The port is Yokohama, at the entrance to Tokio Bay, with an enormous trade. Further south is Nagoya, the largest town on the Tokaido line, which connects Tokio with Kioto, the ancient capital situated near Lake Biwa, the largest lake in Japan. A few miles distant is Ozaka, already mentioned. The chief port of Southern Honshiu is Kobe, on the Inland Sea. In Shikoku, Tokushima is a flourishing town. The commercial centre of Kiushiu is Nagasaki, a fine harbour, near rich coalfields.

Formosa. Formosa is mountainous in the east, where the cliffs rise sheer 6,000 ft. from the Pacific. The mountains are densely forested and inhabited by wild head-hunting tribes. Camphor is the chief product of this region. The western half is a lowland with good harbours facing China. The Chinese form a large element in the population, cultivating sugar, rice, tea, indigo, fibre plants, etc., in the plains and valleys.

The Philippine Islands. This archipelago, including 1,200 islands (115,000 sq. miles), the largest of which is Luzon, belongs to the United States. All are mountainous, volcanic, densely forested, well watered, and extremely fertile. Tobacco and Manilla hemp are the most valuable products, but all tropical produce can be grown. Many of the varied tribes are at a low level of civilisation. The capital is Manilla, on Luzon.

The Malay Archipelago. Of the innumerable islands which form this archipelago (783,000 sq. miles), the largest are Borneo, Sumatra, Java, and Celebes, all Dutch except part of Borneo; all are mountainous and volcanic.

The climate is tropical. The equatorial belt has rain all the year round, but outside this belt the wet and dry seasons are well marked. The forests are of tropical density, and produce rubber and other useful substances, which are collected by native tribes. They are the home of apes, elephants, tigers, and many exquisite birds and insects. Borneo, the largest island, is as yet little developed. British Borneo, in the north, grows tobacco, coffee, and pepper. Dutch Borneo exports tobacco, pepper, sugar, rubber, and other forest produce, edible birds' nests, and strange produce of the sea, including *bêche de mer*, or sea slugs, a Chinese delicacy, and tortoise shell. The best cultivated of the islands is Java, with fertile volcanic soil, producing coffee, sugar, tea, indigo, cacao, tobacco, spices, rice, and sago. The capital is Batavia, the great emporium of trade in the archipelago. The products of Sumatra and Celebes are very similiar. The Molucca Islands, between Celebes and New Guinea, produce cloves and other spices.

122. FUJIYAMA FROM TOKAIDO

Continued

Group 20
LEATHER
3
Continued from page 3013

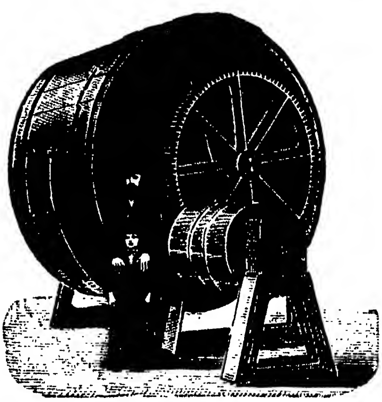
CHROME AND OIL TANNING

Chroming Solution. Departments and Method of Chrome Tanning. Fat-liquoring. Sumach Tanning. Tawing. Alum Tannage. Oil Tanning

By W. S. MURPHY

IN their search for new and quicker methods of tanning, leather manufacturers have tried many substances, and one of the most important results of the quest is the process known as *chrome tanning*. Invented as early as 1858, the process can hardly be said to have settled into a uniform routine, many tanners claiming to have devised special processes of their own. Practically, however, this may be regarded as a harmless and not altogether despicable vanity. The workman who refuses to follow others in a blind routine is entitled to lay a flattering unction to his soul, if he can find it.

Chrome Tanning. Chrome tanning marks the definite entrance into practical leather manufacture of the chemist and the engineer. It is a chemical process chemically controlled, and operated by machinery. In some tanneries chrome is combined with vegetable tanning, and the old pits are used; but that system is like the attempt once made to combine wood and steel in the armament of battleships, and doomed to similar extinction. The chrome-tanning department of a great belt works presents a fair picture of what the tanneries of the future will be like. The open yard and the tan pits are gone, and instead there are the revolving drums, the whirring machinery, and a laboratory annexed. Cavallin, a Swedish apothecary, invented a process of chrome tanning; but it was not of much practical value, his use of iron salts making the fibre of the leather tender. Swan, the electrician, patented a process; but he, too, failed to make it practical. Heinzerling, a German chemist, invented the first chrome process to be of any practical use, in 1879. Though not a complete success, Heinzerling's process showed the way to other and successful inventors. The first adaptation of the principle which became really industrial was devised in America by a New York chemist named August Schultz, in 1884. This patent was brought over the Atlantic, and successfully operated. Subsequently, manufacturers of tanning chemicals, British, German, and American, patented chrome mixtures, and sold them to the trade, with directions, thus universalising the process.



6. TUMBLERS FOR TANNING
(Joseph Hall & Co., Leeds)

Chromium is a metal, derived from chrome iron ore, our supplies of which are chiefly found in the Shetland Isles. The metal is grey in colour, very fusible, and combines readily with many other chemicals [see CHEMISTRY]. Leaving aside those scientific details which must be studied in the laboratory, we come to the actual operations of the working tanner. He gets the mixture all ready, and his business is to work it properly.

Departments of Chrome Tanning. Chrome tanning, as generally practised, involves three processes: (1) chroming; (2) neutralising; (3) fat-liquoring. The chief tool of the chrome-leather tanner is the drum [6]. This is a huge barrel-shaped wooden cylinder, 10 ft. in diameter, the inside circumference studded with shelves projecting inward, like the paddles of a water-wheel. On the spindle which drives the drum three spokes are fixed. By means of the spokes and the paddles the hides are tossed to and fro in the liquor. The drum is partially filled with liquor—about 10 lb. chrome alum to 100 lb. of pelt—and the hides plumped in; then the door is closed, and the driving belt put on. For as long as seems necessary the drum keeps revolving night and day, and the skins come out yellow in colour and impregnated with chrome.

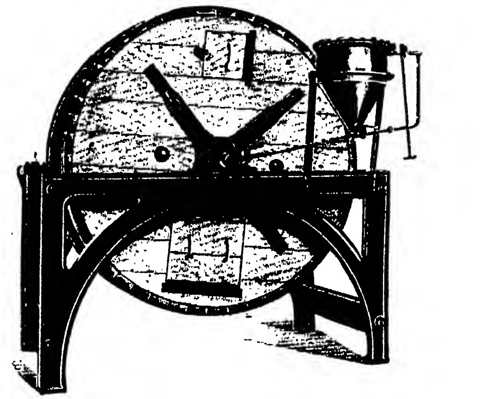
Removing the Chrome. The goods are now tanned, but the acids in the chrome would quickly eat into the fibres if left free to act. Several mixtures are recommended as efficient neutralisers; but our old friend boric acid, beside being familiar, has the merit of acting quickly and effectively. Having been washed in warm water to take out the intense yellow tint, the hides are placed in the neutralising drum, and it is set going on its round of duty. The composition in the drum varies greatly, but the best authorities advise 1 part of boric acid in 200 parts of water.

Fat-liquoring. In ordinary vegetable tanning, the application of fat or grease is considered the business of the currier, or finisher; but fat-liquoring is an integral part of the chrome-tanning process. If allowed to dry after coming out of the neutralising drum the leathers would become hard and stiff. Flexibility in light leathers, and in all classes of belt leathers, is an essential quality. The liquor is an emulsion of soap and oil, in warm water, the proportions varying with the kind and quantity of both ingredients. Castor, cod-liver, and olive oils emulsed with soft soap, curd soap, or wool

grease, give the best results; but if he wants cheaper oils, the tanner may experiment with any mineral oils and alkaline soaps he fancies, and work them in the drum [7]. The mode of operation is simple, the great point being to keep the hides constantly immersed in the emulsion, thus securing thorough permeation. Chrome leather tanning produces a very flexible, tough leather, specially serviceable to the machine-belt maker. Unlike most other mineral tannages, the chrome-tanned leather does not stretch, and this, it is obvious, must be regarded as the highest quality for the purpose named.

Sumach Tanning. The aim of sumach tanning is not so much to produce hard-wearing leather as leather that will remain unaffected by atmospheric and noxious gases. Hence most of the leathers which have come down from ancient times have been sumach-tanned. It is a curious fact that this soft leather, almost fragile, remains untouched by sunlight, gas, or change of temperature, while the stolid, strong sole leather crumbles under the rays of the sun. Manufacturers who specialise in bookbinding, upholstery, and ornamental leathers, adopt the sumach process. It is very seldom that this tannage is employed on any but the lighter skins, such as calf, goat, sheep, and seal. As has been already shown, these skins pass through the processes of puering and drenching, coming to the sumach tanner white and soft. The sumach liquor is warm, and either in a drum or a small tank worked with inside paddle [8] the skins are permeated with the sumach. For many generations the tanners of the East have practised a method of sumach tanning which has been adopted to a considerable extent in this country and in America. This is to sew the skin in the form of a bag, flesh side out, to fill the bag with sumach liquor, and to let it float in the drum or tank till the weight of the skin has expelled the liquor from the bag. Sometimes the liquor is expelled by slow pressure. This produces a leather with a soft, velvety feel.

Tawing. Kid and glove leathers are chiefly produced by what is called the *alum* or *tawing* process. Lamb, calf, and kid skins are treated in this way. Young and tender as they are, these skins must be gently treated. Two methods are adopted, with minor variations, the one being more generally employed on calf and kid skins, and the other on lamb skins. At the risk of slight repetition, we will go rapidly through both processes from start to finish.



7. TANNERS' AND CURRIERS' DRUM

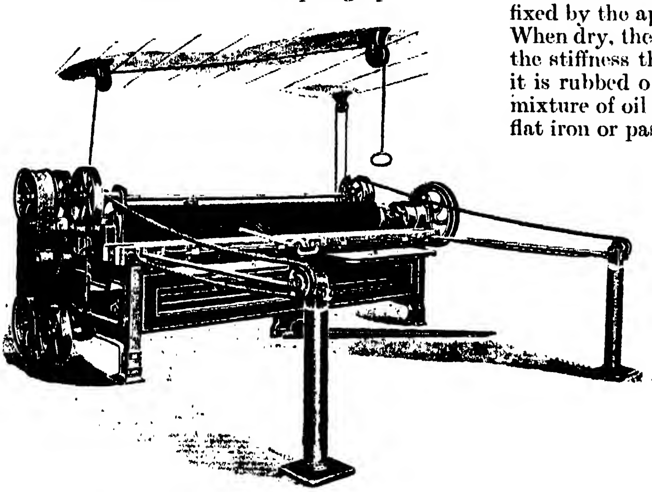
Tawing Lamb Skins. If the skins have been dried, they must be steeped in cold water for three or four days, and then worked on the beam with a blunt knife to make them pliable and to open out the fibres. When made supple, the skins are stretched on boards, flesh side up, and coated with milk of lime. Laid in piles, the limed surfaces in contact, the skins are left for about ten days, when both the fat glands on the inside and the epidermis on the outside will have been thoroughly loosened. With a blunt knife, on the convex block of wood we term the *beam* [2, page 2854], the skins are divested of hair and washed in weak limewater. Taken out again, the pelts are run over on the beam on the flesh side with a knife, and freed from the flesh and inner cellular tissue. Washed once more, they are puered in a concoction of dog's dung, or erodin, and now become soft, velvety, and flaccid.

Fleshed carefully [9] to remove any excrescences which may have escaped the first fleshing, the skins are rinsed in warm water, beaten, paddled in cold water, and *perched*—that is, worked over the beam with flat plates of vulcanite to remove any fat or lime compounds that may have remained. Now they are washed, and then pass into the drench-tub, where the bran ferment separates finely the fibres for the alum tannage.

Alum Tannage. At this point a difference between the practices of Scottish and English tanners must be noted. English tanners make up one tawing liquid, and the Scots make two. The latter process is the slower. A liquor is made up of alum, salt, and water, the strength depending on the thickness of the skins to be tawed, and through it the skins are drummed.

8. TANNING IN PADDLES
These photographs were taken in Elswick Leather Works, Newcastle

After this, the paste, consisting of flour, wheaten bran, and yolk of eggs, is put into the drum, and the skins worked till they have absorbed nearly the whole of the paste. In English tanneries, the practice is to make a mixture in the following proportions: 5 per cent. flour, 2·5 per cent. alum, 1 per cent. salt, the yolks of 25 eggs, 2 oz. of olive oil, and 1½ gallons of water to every 100 lb. of wet pelts. Then the whole is mixed together, the water being at 100° F., the flour in the form of a smooth paste being added first, and next the oil and the eggs well beaten together, and finally the alum and salt. The pelts are put in this mixture, and the tawing done in single operation. The finishing processes for all tawed leathers is almost the same, and we shall therefore treat them in a final paragraph.



9. FLESHING MACHINE (Joseph Hall & Co., Leeds)

Tawing Calf Kid. After being washed and softened, the calf skins are limed in fresh lime in the style of the large hides, unhaired, washed, and worked on the beam. The drenching differs from that applied to lambskin, being done more thoroughly, as a partial substitute for puering. The above mixture is also applied to the calfskin, but the process of tawing is longer, because of the greater thickness of skin. When fully tawed, the skins are allowed to lie a day or two in a tank, to let them take up all the mixture they can hold, and, when partially dry, split on the band knife [10], to be described in a later section.

Ageing and Finishing of Tawed Goods. Tawed leathers are dried in a warm atmosphere, though not too quickly. When dried, the leathers are hard and horny, and to soften them a process of *staking* [11] is carried through. Small skins are slightly damped back and worked vigorously, first over a blunt blade fixed in a post, and then under a rounded blade of hard wood called a *moon knife*, because of its shape. Several times the skins are damped back to ease the fibres and allow them to stretch without breaking, and staked over again. Lambskin and calf kid are staked on machines of various shapes, the most common being the Slocomb, a two-armed tool, the one hand holding a pair of small rollers and the other a pair of blades, working backwards and forwards, at each turn letting the leather slip a little. When the workman is satisfied that no more staking need be done at this time, the skins are put away to age, or season, for a period of about three months, to fix in the alum of the tawing mixture. In time the skins are brought out again and wetted throughout to take away all the superfluous tawing matter, and to soften for the dyeing. Then the leather—for it is no longer skin—is put into a mordanting bath of soap and ammonia.

Dyeing. The common colour is the yellowish flesh tint, and this is made up of two-thirds logwood and one-third fustic, with a small addition of soda. When dyed, the colour is fixed by the application of a wash of iron liquor. When dry, the leather is staked again to take out the stiffness the dye may have imparted; then it is rubbed over the grain or hair side with a mixture of oil and wax, and ironed with a heavy flat iron or passed under a brass roller. To the ordinary eye the leather seems quite finished, but we know better. The gloss is not permanent, and to make it so we take a mixture of olive oil, tallow, beeswax, resin, and gum arabic, and glose it all over the surface of the leather. This fixed by glassing, we give each skin a rub up with a flannel dusted with French chalk, and our goods are ready for the glover, or whoever will buy.

Oil Tanning. Vegetable and mineral tannings produce leathers with a certain quality of firmness, which, though highly necessary for boots, saddlery, harness, and driving belts, does not suit purposes requiring a material combining softness, mobility, and strength. Tawing produces soft leathers; but that process adds little, if anything, to the strength of the skins, and is hardly applicable to heavy hides. In a word, we want a leather equal in most respects to cloth. George Fox, it is true, made himself a suit out of ordinary leather; but George was a kind of martyr and stoic, and that class of man is never sufficiently numerous to keep an ordinary tannery going. If leather is to be worn by ordinary mortals it must be soft, warm, and comfortable, as well as more durable than woven cloth.

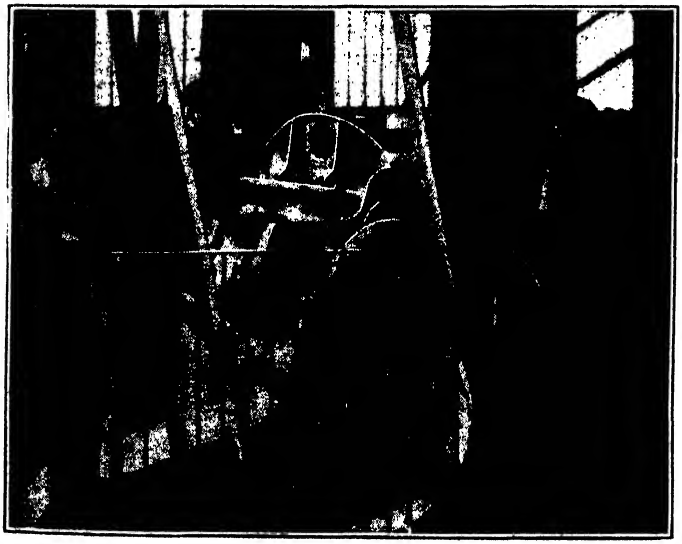
Perhaps the modern leather manufacturer should have left the clothing market to the rivalries of textile workers, though it is risky to venture such an assertion. Modern competition drives industrial enterprise to great lengths; when we see papier mâché offered in lieu of steel for waggon wheels, and spun glass for silk, it is possible to believe that any industry may encroach on the domain of any other.

Soft Leathers. The modern leather manufacturer, however, was spared the trouble of initiating the soft leather industry, that which enters into competition with certain cloths. At the time when the textile workers were just

beginning to learn their craft in Europe, the leather men were supplying their fellows with clothes. It was soft leather Achilles wore under the armour he donned to avenge the death of his friend Patroclus in that momentous struggle between the East and the West long ages ago. Nearer to our time, and more certainly, the mail-clad warriors of mediæval Europe shielded their skins from the hard and cold steel clothes so fashionable then with underclothing of warm chamois leather. The secret, as we have hinted, was discovered long ago; very early in European history men learned that the skin of the little deer living on the higher slopes of the mountains of Greece, the fastnesses of the mountains of Switzerland, the Balkans, and Central Europe, could be made into a soft and durable covering. We live in the days of the far-flying bullet and the street constable, and the soft leather that saved knightly skins from the abrasions of armour-joints now chiefly serves as a kind of superior washing cloth. It is used for purposes more dignified, perhaps, but that need hardly concern us. The important point for the leather manufacturer is that there is a constant and large market for his product, whether it be used for washing windows and cleaning silver or for lining the crowns of sceptred kings.

11. STAKING

Principle of Oil Tanning. Oil tanning is based on the fact that certain oils combine with the fibrin of skins, and act, not only as preservatives, like other fats, but also as strengtheners of the fibre. Most of our chamois leather is now derived from the split skin of the sheep. We have not dealt fully with the splitting of skins hitherto, because splitting is a finishing process in this country for the most part. British tanners prefer to split the hides after they are finished. Suffice it to say, at present, that for the purposes of the glove-leather maker and the manufacturer of parchment sheep skins are split by means of a band knife. The grain side of the skin is taken for these purposes, and the flesh half is given over to the oil tanning department, for the production of what is technically called *washleather*. The splits have already been limed and washed, and the first thing the shamoyer does is to clear away the fatty inner layer with a sharp knife. The operation is not unlike fleshing, but the knife is keener and drawn with sharper force, scraping away all the fatty layer. Having been thoroughly drenched in the bran ferment, the skins, as they may be called, are drained. If allowed to dry in this state, they would become as stiff as boards.

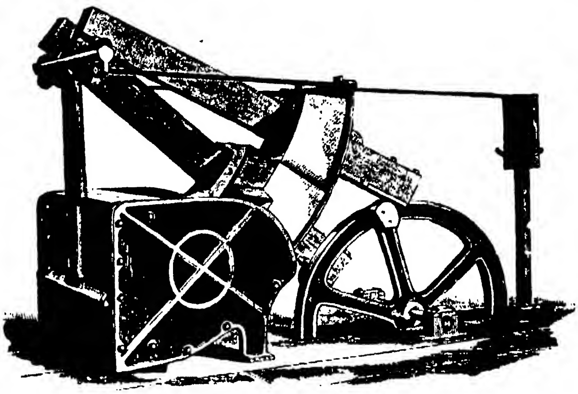


10. BAND KNIFE SPLITTING

The Fulling Stocks. To make the skins flexible, we put them into the *fulling stocks* [12], those elephantine wooden legs that beat, beat on the sloping trough and drag the skins along bit by bit, pounding them into flexibility. Other models of fulling machines are now used, the favourite form being a pair of wheels that oscillate on each other.

The skins do not go into the fulling machines alone. If they did they would be beaten to fragments. Water as an emollient is out of the question, as we shall presently see, and, instead, a layer of soft

sawdust forms the base on which the strokes of the stocks descend. In addition, however, the British shamoyer adds the cod-liver oil, which is his tanning medium, while the skins are going through the stocks. French and German workers take a different way; but we add slowly the oil to the skins while they are being beaten. Every now and again the skins must be taken out and hung up in a warm room to avoid too great heating through friction. When the skins are out to recover, it is well to coat them all over with the cod-liver oil, and to see that no hard bits are left; otherwise, the leather will be spotty and irregular. The stocking must be continued for many hours, till every fibre of the skins has got as much oil as it can carry. The worker may estimate how the process is proceeding by the gradual disappearance of the limy smell, and the emanation of a pungent mustard - like odour from the skins.



12. STOCKS FOR SOFTENING HIDES
(Joseph Hall & Co., Leeds)

Heating. When sure that the skins are thoroughly saturated, the workman stops the stocks, and takes out the skins, examining each one carefully, then laying them in boxes to heat—that is to say, the process of oxidation of the oil sets in. At first great care must be taken lest the heat should gather too quickly and burn the fibres. It is a safe rule to take out the skins after they have lain a short time in the boxes, and lay them out on an open floor to cool. Do this at intervals till the skins cease to give off the pungent odours which bring the water to the eyes. By that sign alone it is evident that oxidation has ceased, and that the skins have been tanned.

Washing and Bleaching. Now the skins are ready for washing. First, however, we should try to recover some of the valuable cod-liver oil which lies unabsorbed by the skins. In the old days, English manufacturers simply washed the skins in strong lye, and recovered the oil by the use of acids; but of late a more economical method has been adopted in many factories. The skins are steeped in hot water, and put under the hydraulic press, recovering a quality of oil which passes into the market as *degras*. Next, the skins are put into a bath of washing soda, and washed thoroughly. While yet damp from the washing, the chamois or wash-leathers are laid out to bleach, watered every now and then with a fat liquor, or an emulsion of degras. The bleaching leaves them of a fair white colour if it be carried out thoroughly, though for the common wash-leather of commerce that is not necessary. It is an important quality of chamois, however, that it bleaches to a pure white if desired.

Products of Oil Tanning. Oil tannage is used to produce several forms of leather besides chamois. In fact, the process is so simple and effective that we are rather disappointed at the slow progress the process has made. Buff leathers for military accoutrements are made from ox hides by this process, the grain side having been scraped off. Curiously enough, the reins and straps used by the Boers of South Africa are prepared by a kind of oil tannage. Cut spirally from the raw hide, and dipped in fat, the thong is wound into a skein and hung from a cross-bar with a heavy weight at the end. Every now and then the fat is applied and the twist of the thong changed, till all the water has been expelled by the pressure, and fat has taken its place. By this means leather straps of great strength and durability are made.

Continued

Continued from page 2871

THE DOUBLE-BASS

Three and Four String Basses. Attitude. Tuning. Fingering. Scales. Intervals. Time. Positions. Pizzicato Effects

By ALGERNON ROSE

TOO much importance can scarcely be attached to the double-bass in an orchestra. It doubles the bass part of the violoncello and is the literal foundation, or "base," upon which rests the entire instrumental superstructure. It is easy to understand, therefore, why the smaller bowed instruments should be named after the great violone.

Three and Four String Basses. There are two kinds of double-basses in general use. They are known as the English and the German. The former is provided with three strings, an arched bass-viol bow, and is capable of great power; whereas the latter has four strings, and a straight bow of 'cello pattern is used with it. Modern composers write chiefly for the four-stringed bass, because it can descend a fourth lower in tone than the instrument with three strings. The temptation of getting four additional bass notes, rather than consideration for tone quality, has been the chief cause of the general adoption of the German system of stringing.

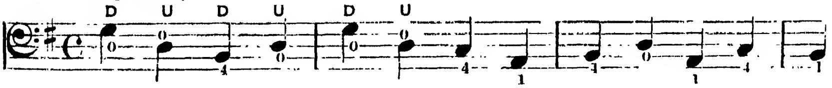
Execution and Tone. But the fact remains that a good player on the triple-strung English bass can elicit a more telling tone from it with the old-fashioned bow than can the performer on its quadruple-strung Teutonic cousin. Advocates of the four-stringed bass emphasise that certain Italian makers originally planned the biggest pattern of fiddle to carry four strings. They argue that the restoration of the fourth should not lessen the tone of the other three. But they conveniently overlook the fact that the reduction of the six strings to four on the treble viol, during its evolution into the violin, immensely enriched its tone.

The beginner, whatever he does later on, had better first learn the English double-bass with three strings. An instrument of fair tone is obtainable in Great Britain, nowadays, for about £5. As soon as the student is able to help in an orchestra, he will find that, like the kettledrums, the society generally provides an instrument for the double-bass player. Excepting in large professional orchestras, such basses have three strings. So useful are amateurs who can play this instrument with tolerable reliance, that, in many societies, not only is a bass hired for them, but they pay a smaller annual subscription than the other members.

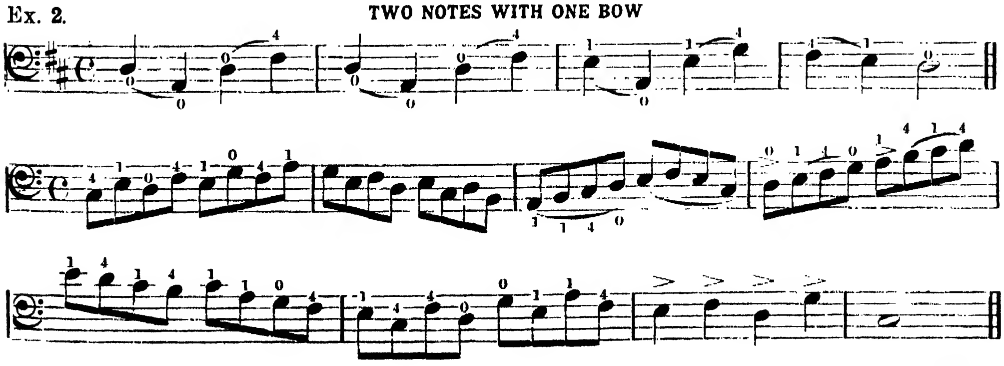
Attitude. On account of the size of the double-bass, the performer stands to play. During lengthy practice a useful support will be afforded by the ledge of a high stool. Grasp the neck of the bass near the head, place the first finger of the left hand on the middle string, put the thumb on the opposite side of the neck immediately underneath, and rest the third and fourth fingers on the third string. Place the left toe under the bottom edge to keep the bass at its proper angle. Suppose the bridge of the instrument represents the centre of a clock-dial and the neck its long minute hand; if the latter points to the hour of one, the angle is correct.

With the right hand take up the bow. Put the thumb on the hair inside, and near, the nut. Rest the other fingers above the thumb on the stick. The instrument being

Ex. 1. *Very slowly.*



Ex. 2. TWO NOTES WITH ONE BOW



at an angle to the player's body, it would be awkward always to bow parallel with the bridge. It is therefore customary for the bow to incline downwards towards the bridge from the third to the first string. The point of the bow, when on the first string, should be just over the top of the left sound-hole.

Tuning. Even as the pitch (A) of the first string on a violoncello is an octave below the pitch (A) of the second string of the violin, so the harmonic A of the third string of the English double-bass can be tuned an octave below the A, or first string, of the 'cello. As this A is a very deep note on the bass, it is better to begin with the first string. Tune this in unison with the G, or third, string on the 'cello. If the pitch is taken from a piano, tune to the G, fourth space, bass clef. Instead of scraping forcibly, a less distracting method is to place the tips of the fingers of the left hand lightly on the middle of the string.

Harmonic Sounds. This plan, when the note is bowed, will give the harmonic, an octave above the actual open sound. Having raised or lowered the peg of the string first until the harmonic is in unison with the tone of the fourth string of the violin (G, fourth space, bass clef, on the piano) take the hand off and bow the string. Its open sound will then be G, first line, bass clef This gives what is known as the tone of an 8 ft. organ pipe. Tune the second string to D, in the same way by the harmonic, a fourth below the first. Lastly, tune the third string to the 16 ft. A, a fourth below the D. This is the English method with the three-stringed bass.

Unfortunately, there are other systems. Although violins, violas, and 'cellos are uniformly tuned to the same notes in different countries, the French tune their three-string basses in fifths instead of fourths. This is awkward for the hand. In France, therefore, in place of the first string being G and the third A, the first is A and the third becomes G.

The beginner is warned not to adopt the French method nor to lower the A string to G, as is often done. When the double-bass is tuned, English fashion, in fourths, the scale lies under the hand more conveniently. Moreover, when progress has been made and the student takes up the four-stringed bass, he will find that instrument also is tuned on the first, second, and third strings to D, G, and A in the way he has learnt. The new string will then be E, at a similar interval of a fourth lower down the scale.

Fingering. The reason why tuning the bass in fourths instead of in fifths, as obtains on the 'cello, viola, and violin, is more convenient is because of the greater length of the strings. These necessitate longer stretches of the left hand for stopping the ascending or descending notes. Thus, when four fingers are placed close together they represent the natural position, or an interval of a half-tone. If, on the other hand, the fingers are spread out, they occupy the space necessary for stopping the interval of a whole tone. The student who grasps this idea has the fingering of the double-bass in a nutshell. When the notes do not occur on an open string, they are usually produced either by the first finger singly, or all four fingers together. In double-bass music, these methods of fingering are indicated by Exs. 1 and 3.

Play the open note of the third string, A. Use the bow from end to end. Count ten slowly. Then place the first finger firmly on the same string; at the same time sound the note B with a full bow. Close the four fingers to get the half-tone above, and with the next bow play C. Without pause, sound the open note of the second string, D. Play the E above with the first finger.

But the pupil will perhaps say that it is the E below. It must be remembered that the expression "up" or "down" the fingerboard of the double-bass refers to the ascent or descent of the tone; it does not relate to the direction in which the scroll of the instrument points. With the four fingers closed to make the semitone "above" E, play F. Continue on the first string, sounding the open G. With the first finger get the A above. Separate the four fingers for the whole tone B. The beginner will now have played a full octave and one note. Descend the scale by stopping each interval in the same manner.

By changing the order of these notes, the student can familiarise himself with the different intervals by a variety of exercises. Practise these very slowly at first. Cultivate a good tone rather than a rapid execution, especially in the lower register of the instrument. To play the double-bass well requires muscle. It is excellent for one's health, because it expands the chest, strengthens the arm and wrist—in fact, professional double-bass players are noted for living longer than any other class of musicians.

Not a Transposing Instrument. In writing out exercises, the student will note that all sounds for the bass are indicated an octave higher than their real pitch. Not only does this facilitate the reading of double-bass music, but it allows the 'cello and double-bass parts to be indicated by the same notes, those for the former instrument having their tails turned up, and those for the latter their tails turned down. It is incorrect, therefore, to call the double-bass, as some pedagogues are fond of doing, a "transposing" instrument. Unlike the A♮ clarionet, or E♭ trumpet, which transpose their sounds mechanically to other regions of pitch, the double-bass always emits similar sounds to those written. The player, therefore, who is a purist, has only to imagine the words "8ve lower" written over the bass part to satisfy his conscience. If, as sometimes happens, a composer writes below the possible compass of the double-bass, the critic can then mentally obliterate the words referred to. The double-bass will do its best by putting in the notes in unison with the 'cello.

The Scales. Now take the scale of G major, with one sharp, F. Begin with the open note on the first string. Spread out the four fingers on the second string to get F♯, instead of closing them, as was done for F♮. With the

first finger, make the next note, E. Then sound the open D. Bow slowly. Count, so as to make each stroke equal. With the four fingers closed on the third string, stop the C. Make the B, half a tone lower, with the first finger, and the A with the open note of the third string. This does not complete the octave, but it accustoms the player to the F♯ on the second string.

Try the scale of C major. Begin with the four fingers closed on the third string. As before, get the D and E on the second string. For the semitone F above, close the four fingers. As previously, make the G and A on the first string. Separate the fingers to get the B, a whole tone above. To play the C, a semitone beyond the natural position of the hand, shift the latter up the neck (or down, in a gravitational sense) till the four fingers, close together, stop the sound.

Alternative Fingering. There are alternative methods of fingering these same notes. The student should familiarise himself with them. We refer to the first string, from G, fourth space, to the C above and back again. First, there is the fingering already indicated. Secondly, play the open string. Then stop A with the first finger. Carry up the same finger to stop B. Next, with all four fingers close together, play the semitone C above. Return in the same way. The usual plan is to play these notes, interchanging the first with the four fingers, by stopping the A with the first finger, the B with the four fingers, the C with the first finger, going back to the four fingers for B and the first finger for A. But this system carries the whole hand higher than necessary up the fingerboard. In double-bass playing, one of the arts is to avoid wasting energy by superfluous shifting of the left hand. Besides being unsightly, it is fatiguing. It makes the performance uneven instead of, as it should be, firm and clear.

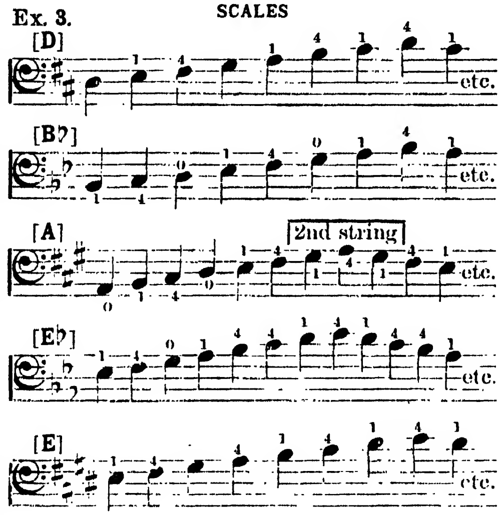
Hand Movements. Remember, therefore, not to move the whole hand about unprofitably. Practise slowly, and restrain the desire to run before learning to walk. So that the hand may come into its right place without thinking about it, and passages may be fingered readily and correctly, the student must be careful to be right in his first attempts. The road to success is by regular daily practice. A steady quarter of an hour of slow, strong bowing three times a day, with intervals in between, does more good than an hour's unbroken practice, during half of which time the beginner may feel over-tasked by the unaccustomed strain on his muscles.

To continue the double-bass when fatigued and the hands are aching is unwise. At such a time, stop practising and give the muscles a rest. Then, with recovered strength, try again.

Now try the scale of D major with two sharps, F and C. Begin on the second string. Bow the open D. With the first finger get E above. Put down the four fingers spread out for the F♯. Sound the open G of the first string. Whether the bow makes a downward or sideway movement, take care to keep the right wrist free. Although, later on, the straight bow of 'cello pattern may be used, the student who practises with the arch bow should be able to get a greater amount of force of tone from it and attack the strings better.

A Lissom Wrist. But the effect will be spoilt if this is done with a stiff wrist. The wrist action must be unconstrained. Dragonetti considered the arched bow superior to that with the straight stick, and the pupil cannot go far wrong who uses a bow similar to that of the great Venetian double-bass player, who educated himself in the guitar and violin, and was able to take a place in an orchestra at the age of eleven. From that period he played the double-bass continuously for no fewer than eighty years, never getting tired of it, but always revelling in its beauties.

Ex. 3. SCALES



Having bowed the open G properly, put down the first finger for A, spread out the four fingers for B, stop with the first finger the C♯, a whole tone above, and put down the four fingers closed for the semitone D. Descend the scale with the same fingering.

Intervals. Proceed now to practise the intervals of thirds, fourths, and fifths. First get accustomed to these in the key of G. Note down all such exercises on paper, and transpose them into C major and D major. By such means the student will get an insight into the elementary principles of bass playing. We give specimens of exercises that can be easily supplemented. "U" denotes the up-bow, and "D" the down-bow [Ex. 1].

Next, practise the major scales which have up to four flats and five sharps in their signatures [Ex. 3].

To acquire facility in the necessary shifts of the left hand up or down in diatonic passages, persevere day by day with the exercises given in Ex. 2 till they become automatic.

Bowing. Now go back to the scales. Play every two notes with one bow, then every three notes with one bow. Making the tone as smooth as possible, try to get every successive four notes with one bow. Play alternately with an up and down stroke. Determine to

make the voice of the instrument, deep as it is, sing out evenly with a cantabile effect.

Staccato. That method of bowing which is the reverse of cantabile is done by separating each note abruptly. It thus appears to be detached, although the bow is not taken off the string. This is called staccato playing.

Practise the scales systematically, repeating each note so as to make two short, abrupt sounds with each bow instead of one long one. Next make three short sounds with each bow. Then alternate the cantabile with the staccato style, by slurring the first pair of four notes with an up-bow, and making the next pair crisply with a down-bow. Write out these exercises on music paper, and go over the same ground day by day.

Time. It is necessary for the student, when practising even the simplest studies, to cultivate a sense of time. The double-bass is called the metronome of the orchestra. It is essential, therefore, for the player of this instrument to be a good timist; and to be a good timist he must possess confidence. No double-bass player who distrusts himself can reasonably expect the confidence of others. The glory of the double-bass player is in his strength, and, as hesitation is a sign of weakness, if he hesitates he is lost. If he plays irresolutely, he may upset all the other performers. Cultivation of the time sense gives certainty to the student's playing. It is more important to attack emphatically the first note of a bar than to try to put in all the sounds preceding the conductor's down beat and be half a second late. The violins may flutter about like flags on a mainmast without much damage, but if the great double-bass, representing the keel of the vessel, is uncertain, the result is disaster.

Rests. It is a good plan to train oneself with rest studies. Count carefully when practising, not only the notes which have to be played, but the signs which enjoin silence. Rest exercises may be engaged in profitably when the student begins to tire after a spell of vigorous bowing. Take the exercises already made in various keys and substitute for certain of the notes their time equivalents in rests. Thus, if the study is in common time, and each bar contain four crotchets, arrange so as to play the first bar, keep silence during the second, when the rests must be counted carefully; play half the third bar, counting two crotchet rests to complete it; omit the first note of the fourth bar, counting a crotchet rest before playing the next three notes, and so on.

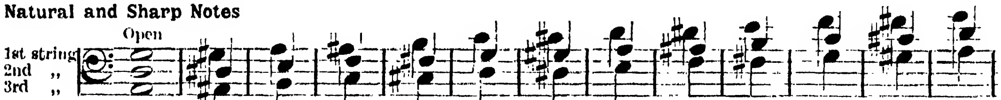
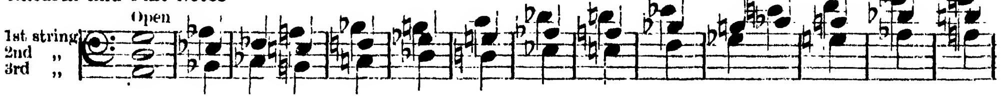
Higher Positions. Consideration of the best situation for the left hand leads up to the study of the higher shifts in double-bass playing. These go by semitones, and are reckoned by each successive new position of the first finger. After the first finger has been properly placed, the notes above are stopped consecutively by all four fingers—closed or extended as the interval is a half or whole tone—the next note being pressed by the first finger, and so on. Thus, by gliding the hand backwards and forwards on the three strings, the same sound may be produced in different ways, and changing the strings during one stroke of the bow rendered unnecessary. We give the different fingerings to show the notes that can be stopped by the same digits on the same strings [Ex. 4].

With the above key, the thoughtful student may compile exercises throughout the compass of two octaves, adjusting the fingering to enable him to take up any position instinctively.

Pizzicato. A pizzicato effect is obtainable from every variety of instrument furnished with strings, except the pianoforte. On the violin its production is often brilliant in orchestral passages. Owing to the extent of the vibrating surface, the effect of the plucked string, however, is grandest on the double-bass. When such notes occur, they are marked "pizz." To accustom the student to pulling and letting go the strings with the right hand instead of bowing them, and so obtaining the pizzicato sounds, a useful exercise is to practise four bars with the bow, four bars pizzicato, and so on.

Harmonics. Of less use to the orchestral double-bass player, save for the purpose of tuning, is the production of harmonics. Yet these are obtainable with greater facility than on instruments with shorter strings. By touching lightly the strings of the double bass at their different acoustical nodes, the series of overtones can be extended in a manner impossible on the violin. For solo playing these sounds are very effective, the so-called flageolet, or harp tones being exceptionally beautiful. Nevertheless, the function of the double-bass in the orchestra is to sustain or mark the pedal or fundamental notes, whilst other instruments supply the overtones to those fundamentals. For that reason, despite the extensive compass of the double-bass, composers do not write for it above G, an octave over the open note of the first string.

Ex. 4.

Natural and Sharp Notes

Natural and Flat Notes

Double-bass concluded

RAILWAY EARTHWORKS

Tools and Implements. Hand and Mechanical Labour. Barrow and Waggon Handling. Details of Tipping

By R. W. WESTERN

THE *earthworks* of a railway usually account for about a fourth or a fifth of the total cost of construction. It is here that the greatest scope is afforded for skilful and experienced management. One who contracts to build a railway will usually be found to succeed or fail according to the ability with which he effects the shifting of the earth.

The actual conditions under which a railway is built are never ideal. However typical the situation may be, untoward circumstances always interfere with whatever arrangements may have been made to build in a preconceived manner that aims at theoretical perfection.

The builder of a railway must, therefore, be resourceful in expedient, and his arrangements must be elastic. Makeshifts are his standby, his main equipment, as a practical man. One who knows only how to proceed by perfectly correct methods is sure to come to grief; and although it is impossible to expound the infinite variety of makeshifts, we shall not follow the usual plan of omitting the description of makeshift devices.

Strength of Earthworks. Earth gives way by reason of the particles of which it consists sliding past each other. This is prevented in two ways: first, by any adhesion which may obtain between the particles, and secondly, by friction. It must be remembered in this connection that solid rock, wherever met with, is included in the general meaning of earthwork as well as ordinary clay, marl, loam, and such soil. In the case of solid rock the force of cohesion is, of course, sufficient to preserve the work in almost any form that may be given to it; though it must be noted that rocks have joints and fissures, and that the material may slip where these occur.

With ordinary earth the force of cohesion may also sometimes be considerable; but seldom, if ever, can it be relied upon as a permanent factor in the preservation of the work. It is in all cases greatly diminished by the presence of water, though often assisted by a moderate amount of moisture; and certain clays, though hard and stiff enough when first excavated, become soft and pasty by mere exposure to the atmosphere.

Natural Slope. The only force that can be relied upon for the permanent preservation of earthwork is the friction between the particles composing it. This is sufficient to maintain the side of an earthwork at a uniform slope, whose inclination to the horizon is the angle of repose, or angle whose *tangent* is the *coefficient of friction.*

This angle differs, of course, for every kind of earth, and is so variable that tables or information obtained from books should never be trusted to determine the slope at which the side of an earthwork should be made. In every case observation should be taken of existing earthworks constructed of the same material, or, in default of these, the greatest inclination of the natural surface of the soil in the locality may prove an even more satisfactory guide.

For the purpose, however, of obtaining a general idea of the behaviour of materials most commonly found, the following table may be consulted. The first column shows the greatest height in feet at which the material can be expected to stand *temporarily*. The second column shows the greatest angle at which it can be relied upon to remain permanently in repose:

	I.	II.
	Feet	
Clean dry sand and gravel	0	36 to 45
Moist sand	3 to 5	36 to 45
Ordinary surface soil..	3 to 6	25 to 40
Common clay ..	9 to 15	30 to 40

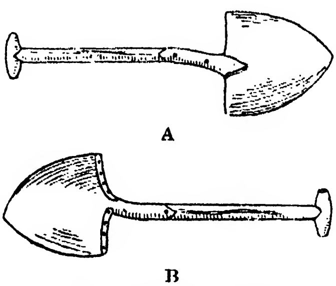
Getting. The word *getting* is commonly used to mean the removal of earth from its natural position, to transport it in the manner and to the place required by the exigencies of railway construction. The mere getting of earth is most economically effected by means of a steam navvy. The steam navvy, however, can be made to work only in an economical and satisfactory manner when it can be used against a sheer face of earth. Hence—as in most cases where a cutting of earth is to be commenced—the earth begins to rise gradually, and in many cases very gradually, the depth of the cut being at the beginning but slight, and a good deal of work has to be done first of all by hand labour.

Whatever recourse may be had to machinery, there is always a great deal of hand labour required in the shifting of earth for railway construction. The cost of this by itself amounts to a considerable sum, the amount of which is entirely determined by the skill with which the work is arranged. The main feature of good management is to insure that all hands are always fully engaged, and that under no circumstances have men to wait while their work is in preparation.

Implements. The suitability of the tools for the work is also important. Even the common and well-known pick, unless it be adapted to the work in hand, will involve an

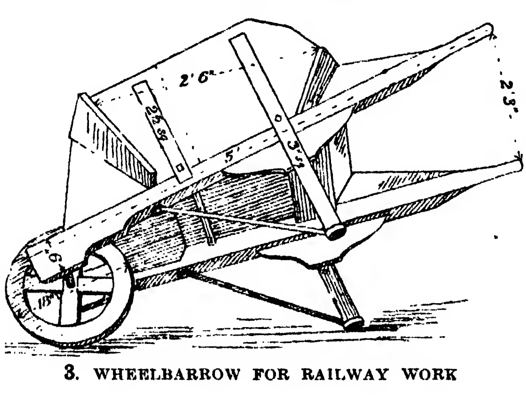
unnecessary expenditure on labour. There are three kinds of pick in common use; those most favoured are A and C in 1. In getting stiff earth the pick is used a great deal as a lever and is very liable to break at the junction of the handle with the steel. For this reason the pick A is most suitable under these conditions; but that indicated by C is more suitable for all-round general work, and is most favoured by workmen. The pick B is most convenient for work that is level under foot. It will be recognised as that most frequently seen in the hands of workmen mending macadamised roads. It is a common plan in America to plough the land before putting the men on; the object of this is to loosen the surface soil, thus avoiding the use of the pickaxe at all. Such a method is, of course, only applicable where the depth to be obtained is very slight, as, for example, occurs in cases where it is considered desirable that the surface soil should be removed before commencing an earthwork.

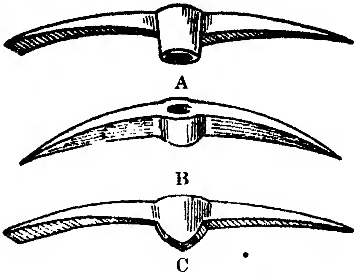
Shovels and Spades. Two kinds of shovel are required, and they are illustrated in 2. They are not of uniform size, the dimensions varying from 12 in. by 10½ in. to 14 in. by 13 in. The main difference between them is that B is provided with treads—that is to say, an extra piece of metal is placed on the top of the blade where the navvy places his foot to drive the shovel into the earth. These treads lengthen the life of the shovel, especially when used for digging in hard soil; but for shovelling earth into barrows or carts, the treads are superfluous and, by adding to the weight of the implement, cause an appreciable increase in the labour of using it.



2. RAILWAY SHOVELS

A spade, including the handle, should not weigh more than about 6 lb. The earth, after being detached in manageable fragments by the pick is placed by means of shovels into either wheelbarrows or small carts, except where the cutting is sufficiently advanced for men to be able to throw the earth immediately into waggons running upon the rail. The latter plan is adopted directly the *gullet*—as the advancing cut into the hill is called—is 4 ft. or 5 ft. deep, provided a proper *tip-head* is prepared. The use of this latter term will be fully explained when we deal with the subject of tipping.


3. WHEELBARROW FOR RAILWAY WORK



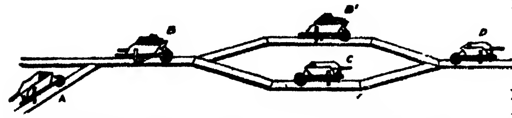
1. PICKS USED FOR RAILWAY WORK

Wheelbarrows. The great point in the design of a wheelbarrow is the distance of its centre of gravity when loaded from the line joining the point of contact of the wheel and the ground to the handles. If this be too great, the workman will find a difficulty in balancing it, and the effort to keep it steady will diminish his daily output of work. The distance in question should certainly not exceed 12 in.

Hand Labour. A wheelbarrow of serviceable size is shown in 3. The men who use picks are called *pick-men* or *getters;* those who use a shovel are called *fillers;* and when wheelbarrows are used the men wheeling them are called *wheelers.* The number of getters must be carefully proportioned to the number of fillers, and the number of these to the number of wheelers, so that the different groups may not have to wait for each other. The proportion of getters to fillers depends upon the nature of the soil. In comparatively new earth an equal number of each will generally keep everyone employed. In a stiff clay, however, one filler will clear away the getting of two pick-men. Only by experience can a suitable relation be obtained. The proportion of the number of wheelers to the number of fillers depends upon the *lead*—that is to say, upon the distance over which the earth has to be wheeled. As a general rule, it takes as long to fill an ordinary barrow as to wheel it along a plank for 100 feet. This, however, only holds good if the plank be level. If the earth must be wheeled up an incline, every foot of increase in the level must be reckoned equivalent to 6 ft. on the level plank. The lead should be so arranged that under no circumstances have loaded barrows to be wheeled up an incline greater than 1 in 12, otherwise the workmen will not be expending their strength in an economical manner.

Barrow Work. When earth has to be transported in barrows a greater distance than one wheeler can go while a filler is filling the barrow, the lead is divided into two, or a greater number of parts, as the case may require. These parts are commonly referred to

as *runs.* Where the runs meet, the planks are laid double for a short distance. Thus, in 4 the barrow A is being filled, while the barrow B is being wheeled away full. When the barrow B has reached the position B¹, it will be left there, and C, the empty barrow left by



4. TRANSPORTING EARTH IN WHEELBARROWS

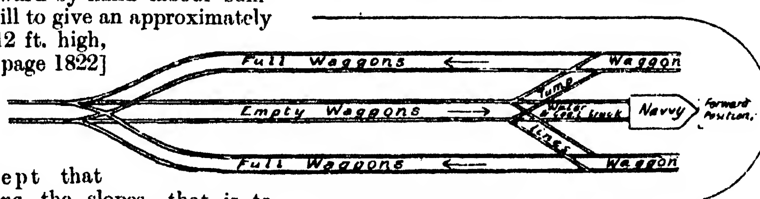
the second wheeler, will be taken back to be refilled by the first. The second wheeler, meanwhile, having placed the empty barrow D he is now taking back in the old position C, will take on the barrow B from its position at B¹. In the figure the barrows are shown turned in the direction of movement; but the English labourer does not so turn his barrow, but trundles it behind him when returning with it empty.

The Steam Navvy. As soon as a cutting has been pushed forward by hand labour sufficiently far into the hill to give an approximately vertical face about 12 ft. high, a steam navvy [see page 1822] may usually be introduced with economy, and all further getting, filling, and barrow work, except that required for *trimming* the slopes—that is to say, bringing them to their ultimate profile—is done by its means.

The steam navvy enables quicker progress to be made than is possible by hand labour, however great a number of men may be available for the work, since it is impossible to get more than a certain number of men at work upon a face of earth at the head of a cutting; and by means of the steam navvy the earth is excavated very much more quickly than it could be by this maximum of men. Its use relieves the contractor of the necessity of getting together so large a number of men, and of housing or otherwise providing for them in out-of-the-way districts. It further renders the contractor or constructor of the railway in a great measure independent of strikes in this department of his business, so that less time is lost in disputes about wages. Thus, when a steam navvy has once been got fairly to work in excavating a railway cutting, it may generally be relied on to continue at a uniform rate of progress until the excavation of that cutting is complete.

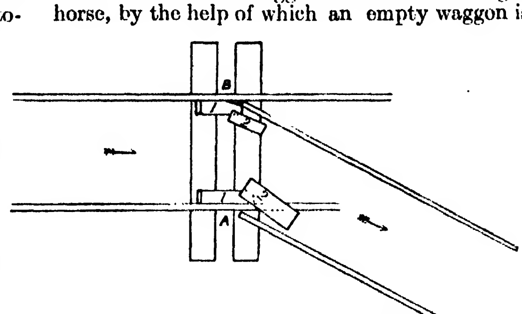
Output of the Steam Navvy. The output is, of course, greatly dependent upon the nature of the earth. For hard stuff a small bucket must be used. But in most cases the bucket attached to the steam navvy may be of $1\frac{1}{4}$ cub. yd. capacity, and in loose earth or sand a bucket of $1\frac{1}{2}$ or even $1\frac{3}{4}$ cub. yd. may be used with advantage. The most disadvantageous material to work is stiff clay containing large stones and occasional boulders. In such cases the capacity of the bucket should not exceed 1 cub. yd., and may have to be even less in order to reduce the liability to accidents. The number of strokes or digs that can be effected in an hour is between 50 and 70, and the average is about one a minute, allowing for all the delays involved in moving forward the machine and in laying fresh rails, etc. This gives approximately 600 bucket-loads per day of 10 hours. Under fairly favourable conditions a steam navvy will excavate a cutting 20 ft. deep, 50 ft. wide at the top and 40 ft. wide at the bottom at an average rate of 8 lineal yd. per day. As to the cost, it is to a great extent a matter of wages. The machine requires a wheelman, a fireman, a man at the top, a ganger, an engine-driver, and eight other men to allow for handling the waggons and for shifts, so that altogether the cost of getting and clearing away the earth with the help of the steam navvy is about £5 a day in England.

Manner of Working. To ensure that the machine shall be kept working at a maximum output, careful attention must be given to the provision for getting rid of the excavated earth. The most effective way is to provide double roads, one on each side of the machine, and branching out from a central road. Immediately behind the machine these roads should be connected by two short crossover lines [5].



5. RAILWAY CUTTING WITH A STEAM NAVVY

A line of empty waggons is kept on the central road between the two side lines, and on each side of the line of waggons is a man tending a horse, by the help of which an empty waggon is brought forward from the line on the central track over the short crossover line and alongside the machine. As soon as a waggon is filled, it is run back along the branch, another empty waggon meanwhile having been brought up alongside the other side of the machine from the central track. Thus the empty waggons are



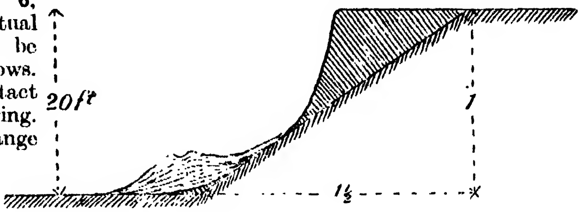
6. ARRANGEMENT FOR STEAM NAVVY WORK

continually being removed from the central track and passed (filled) into the branch line. Each engine bringing a train of empty waggons pushes them up the central track and leaves them there; it then goes back and passes on to the branch line to take a load of full waggons out of it.

The short crossover lines immediately behind the steam navvy have to be continually moved forward as the steam navvy works its way through the cutting. It will have been noticed that only empty waggons are passed over them, and under these circumstances it is not surprising that the roughest makeshifts are found to be economical.

Waggon Provision for the Navvy. A common arrangement is shown in **6**, the details of which are taken from actual practice. The waggon is supposed to be going in the direction indicated by the arrows. The front right wheel comes first into contact with the block of wood 1 at A in the drawing. This block is shaped like a wedge. The flange of the wheel of the waggon rolls up this wedge until the bottom of the flange is on a level with the top of the rail. Further progress at A is then checked, while the left wheel rolls round B, coming up a similar inclined plane to that already described at A, because the rail it has to mount is at a higher level than that it must leave. To prevent the wheels making off bodily to the right and leaving the line, block 2 is placed at B to keep the flange in position. Both the blocks 2, 2, at A and B now help to divert the wheels so that they drop down upon a crossover line with a jolt. It will be seen from **5** that according to this arrangement the jib of the steam navvy has to be swung round a minimum distance at each stroke, the earth obtained by each sweep being delivered on its own side. The gullet thus made may be run to a depth of as much as 30 ft. in loose ground, but the most economical depth is 25 ft., because at this depth the machine has just reach enough to make the cutting of standard size for an ordinary two-line railroad of the usual gauge. It is in making the cutting very much narrower or very much broader than this that extra trouble is involved. When the cutting is narrower there is not room for a line of waggons on each side; and when it is broader, the navvy is unable to reach both sides at the same time, and, consequently, after being run forward as far as the circumstances allow, it must be brought back again and set to widening the cut by excavating on one side of it alone. While so working only one waggon at a time can be placed in position for loading, and the consequence of this is that there is loss of time in changing the waggon, since it requires less time for the navvy to fill its bucket than for the filled waggon to be moved and an empty one put in its place.

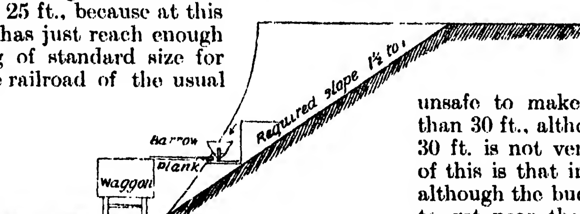
Getting the Waggons into Position. In working along a side face, as in the case just described, there are two ways of getting empty waggons into position. First, a train can be drawn up alongside the navvy, and each truck as it is filled can be pulled backwards by the locomotive, so as to bring the next one to the right position for receiving the contents of the bucket. This method has the advantage of quickness, and eliminates the loss of time alluded to. In practice, however, it is not found satisfactory, except in the hands of a very skilful engine driver, and with a better track than is commonly laid for the waggons.



7. RAILWAY CUTTING AS LEFT BY STEAM NAVVY

Under ordinary circumstances, the engine-driver will fail to move the train just the requisite distance for bringing the succeeding truck into the right position to be filled. The steam navvy will then possibly miss a truck, the movement having been too great, or a great deal of earth may be spilt upon the track because the bucket cannot be brought properly over the misplaced waggon.

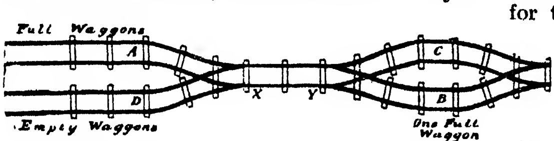
The second method is to store the empty waggons behind the navvy, very much in the same way as was described in **5**, though there can be only one branch line. Of course it is not so convenient, but on the whole this method is more often used than the former.



8. RAILWAY CUTTING, SHOWING GALLERIES

Cutting in Clay. In cutting a very hard and tenacious clay it is unsafe to make the cutting deeper than 30 ft., although with loose earth 30 ft. is not very deep. The reason of this is that in digging loose earth, although the bucket may not be able to get near the top of the cutting, yet, while digging underneath, the upper part falls down; whereas in a hard clay, the digging underneath might proceed for 5 ft. or 6 ft. into the face before the earth at the top gave way, when it would be likely to fall in a mass and injure something in falling. Where the cutting is of excessive height for only a short distance, it is expedient to loosen the earth at the top by means of wedges over this distance, so that only small quantities shall fall at a time. The work will involve the employment of several men, and is very liable to lead to accidents. It is only when the distance in question is too short to make any alteration in the scheme for excavation expedient that it should be resorted to. The alternative is to take out the earth in two layers.

The Steam Navvy's Work. The steam navvy leaves the side slopes nearly perpendicular towards the top, especially when the cutting is deep, and these have afterwards to be trimmed to the proper profile as required for the railway. The most economical method of trimming is put into practice immediately after the navvy has moved on, or at least before the earth has slipped down. Fig. 7 shows the form in which the side of the cutting is left by the navvy. It will be seen that the earth is in an unstable condition, and that its fall is only a question of time. Hence, if the slopes are trimmed immediately after the navvy has left them—that is to say, before the earth has fallen—much labour will be saved, since the workmen have the force of gravity in their favour; whereas, after it has slipped down, they must throw it up again, and usually into railway waggons, which is a high throw.



9. ARRANGEMENT OF LINES FOR SINGLE TIP-HEAD

As shown in 8, galleries should be made along the side of the cut, so that the earth is always thrown downwards, and wheeled along planks as shown, and emptied into waggons alongside.

Obstacles to Steam Navvy Work. One of the chief obstacles to the use of a steam navvy in settled countries like our own arises from the number of bridges which have to be constructed over the line. These may amount to five, or even ten per mile, and frequently have to be built in trenches before the cutting is made. The steam navvy, in such circumstances, cannot be passed beneath it without being taken to pieces, involving great labour and loss of time. In excavating a stiff clay a further objection is found in the condition of the excavated earth. This will consist chiefly of large lumps, 8 cub. ft. in size, and fragments thereof. When the earth is tipped to form an embankment, the large lumps all roll down to the bottom and form the base of the bank, the effect of which is to cause an undue amount of subsequent contraction. This difficulty is discussed more fully under the head of *tipping*.

Blasting. When the earth to be excavated is too hard to yield to the pick, the assistance of explosives must be obtained. Slow-burning explosives, of which gunpowder is the type, are most suitable and economical for soft, tough rock, such as are composed of indurated clays; while detonating explosives of the dynamite order are best suited to hard, brittle rocks, like trachyte. Patent explosives consisting of mixtures of these two explosives are often more powerful than either. An account of the use must be sought for under the head of Explosives. The ordinary methods of blasting are explained under Mining, and the blasting required for railway work does not appreciably differ.

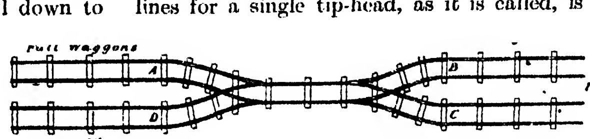
Tipping. Earth is either tipped or filled in order to be got rid of or for some ulterior useful purpose, of which the formation of an embankment is the principal. In cases where such an embankment is too far removed from the site of the excavation, or where, for any other reason, it is inconvenient to use the excavated earth for the purpose of forming an embankment or any other railway work, the earth must be tipped upon waste land purchased for the purpose, producing what is known as a *spoil-bank*.

There are two methods by which an embankment may be filled in the construction of a railway. The first is by depositing the earth in layers about 1 ft. thick, and *punning*, or *ramming*, it thoroughly after each layer is deposited. Punning, or ramming, consists of allowing a heavy weight to fall upon the earth from the height of about 1 ft., to which height it is raised by hand, the man using a staff attached to the weight for that purpose. The process is expensive, the cost being approximately equivalent to 1¼th as much as that involved in loading the earth into barrows. This method is, nevertheless, used in depositing the earth over culverts and in the proximity of bridges and similar openings.

The other method of tipping the earth is to allow it to fall from the waggon or the vehicle in which it is conveyed from the full height of the embankment which is being formed. This is a much easier, more convenient, and a less expensive method of working. It has the advantage also of being very much more expeditious.

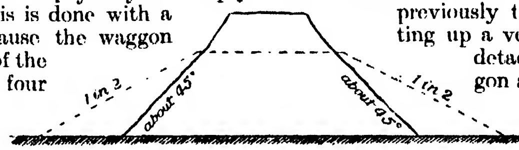
An embankment constructed in this manner may be either tipped to its full width at once by using two lines of way, or, when the work is required to be pushed quickly ahead, a single line may be used for a short distance; but it will be seen from the following description that the single line cannot be made to go very far ahead.

Single Tip-head. The arrangement of lines for a single tip-head, as it is called, is as follows [9]: The engine first of all drags its train of loaded waggons, which it leaves at A in the figure, the line being here doubled to allow a space in which they may stand. All the waggons are then detached from one another and from the engine. The truck nearest the engine is then reattached to it, not by means of the ordinary coupling, but by means of a hook which can be detached by the engine-driver or stoker on pulling a string. The engine now proceeds with this full truck behind it,



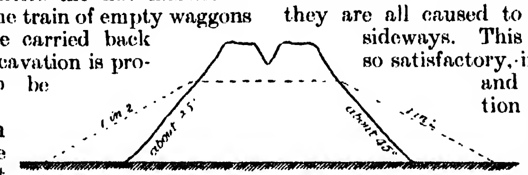
10. ARRANGEMENT OF LINES FOR DOUBLE TIP-HEAD

and moves towards the tip by way of the lines marked B. But before it reaches B the waggon is detached, and the speed is regulated so that the waggon following the engine, in virtue of the velocity already obtained, comes to a stop of itself, and is left at B. The engine, which has been proceeding towards the tip, now reverses, and returns to A by passing along the lines marked C. At A it picks up another full waggon, and this it proceeds to leave at B by the same method as before; but on this occasion, in passing towards the tip along the lines marked B, it comes in contact with the former waggon which had been left at this spot. This it now pushes towards the tip-head. It is not attached to the waggon in any way, it simply pushes it forward. This is done with a sufficient velocity to cause the waggon to reach the extremity of the tip at a speed of from four to six miles an hour. The engine is stopped by putting on the brakes shortly before the waggon reaches the *tip-head,* as the extremity of the tip is called. The contents of the waggon having been emptied at the tip-head, the engine again comes forward, the emptied waggon is attached to it, and the engine proceeds with it at a moderate speed along the lines marked C. Here it again detaches itself and increases its velocity, so that it gets ahead of the waggon and passes along the lines marked A, there to pick up another full waggon. In the interval the points at X have been altered so that the empty waggon following the engine is directed on to the line marked D, where all the waggons, after being emptied, are ultimately stored, by continuing the cycle of operations already described. The engine then passes along the lines marked A, enters the line marked D at the other end, and the train of empty waggons can be made up, to be carried back to the site at which excavation is proceeding in order to be refilled.



11. RAILWAY EMBANKMENT FOR SINGLE TRACK
Showing provisional and ultimate position of earth

It will be seen from the figure that three points are required, at X and Y and Z; but the points at X are the only points that require the attendance of a man, or rather a boy, to operate them. Those at Z may be operated by a weight in such a way that wheels passing from right to left are always directed along the lines marked C, while those moving in the opposite direction open the points for themselves, the pressure of the flange being sufficient to raise the weight. The points at Y can be managed in the same manner, the weight being arranged so as to direct all wheels moving from left to right along the lines marked B.



12. RAILWAY EMBANKMENT FOR DOUBLE TRACK
Showing provisional and ultimate position of earth

Double Tip-head. The arrangements for a *double tip-head,* as a tip-head with two lines of way is usually called, are simpler [10]. The waggons arrive at A, and are left there as before, being detatched from each other as already described. The engine, then picking up the truck first to hand, gets up sufficient speed to enable the waggon to reach the tip-head by its own velocity. This must, of course, be done quickly, for the engine must detach itself and, proceeding at a greater speed, pass on to the lines marked B, leaving time enough for the points to be altered before they are reached by the waggon following it, so that the waggon shall pass on to the line marked C with sufficient speed to reach the tip-head and be tipped.

The engine then returns, and, picking up another waggon, sends it to be tipped along the lines marked B in an exactly similar manner, while the engine itself, proceeding along the line marked C, there picks up the waggon previously tipped, and, quickly getting up a velocity on its way back, detaches itself from the waggon and moves on to the line marked A, leaving the empty waggon behind it to follow at a sufficient distance to allow the points to be altered so as to direct it on to the lines marked D, and with sufficient velocity to carry it up to the line of empty waggons standing there. In this arrangement it will be seen from the figure that only two sets of points are required, both of which, however, require manual operation.

Side Tipping. By means of a double tip-head an embankment may be tipped at once to its full width—that is to say, the necessity for tipping over the side of the embankment may be avoided. This method of tipping earth is very simple, though special waggons are required. These waggons are called side-tip waggons, and where it is desired merely to widen an embankment it is necessary only to bring a train of them on to the embankment, when they are all caused to tip their contents out sideways. This means, however, is not so satisfactory, in spite of its simplicity and economy. The objection consists in the fact that earth has always a tendency to slip in the same direction in which it falls from the waggon, and if, for any reason, the widening of an embankment by side tipping is not completed until some time after the first work has been made, it is possible that the earth subsequently deposited may never become securely united to the previously tipped earth. The effect of heavy rainfall under these circumstances may be to cause a very serious slide in the earth of the embankment, and perhaps a grave accident.

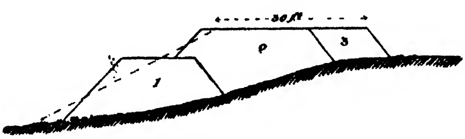
Tipping Embankments of Various Widths. In tipping an embankment for a single line of way the width at the top is generally much narrower than is necessary for the support of the permanent way to be subsequently built; on the other hand, the earth falls down from the waggons from which it is tipped at an angle very much steeper than will provide for the

necessary stability of the permanent earthwork. Under these circumstances it is usual to tip an embankment which is formed under these conditions considerably higher than it is intended ultimately to be. The surplus earth at the top will then be available for easing the slope at the side, as shown in **11**, in which the full lines show the profile of the embankment as at first formed, and the dotted lines as subsequently shaped.

In tipping a bank for two lines of way, it is best to keep the two tip-heads at a good distance apart, as shown in **12**, so that at the top the bank is at first much broader than is required. The full line in the figure shows the profile of the embankment as at first formed, and the dotted lines show the profile as finally shaped. The triangle between the two heads is best filled by running a single tip-head in a line between the two former tip-heads.

Embankments on Sidelong Ground. In **11** and **12** the level of the earth upon which the embankment is tipped has been shown level. This, of course, is seldom the case, and if the slope of the ground in the sidelong direction is considerable it will be necessary to bench it, or cut it into steps [**13**], which should be sloped longitudinally for drainage, in order that the earth tipped upon it may get a firm hold upon the ground. Sometimes, especially in America, a better union between the earth and the ground is sought by ploughing the latter before commencing the embankment.

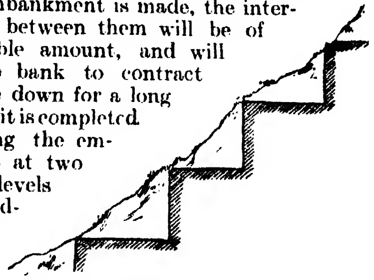
Fig. **14** shows a common way of forming an embankment on sidelong ground. The full lines show the form in which the earth was first tipped, and the dotted lines its ultimate shape. That part of the section numbered 1 was tipped first by means of a single tip-head, and this formed a toe to the main part of the embankment numbered 2, which was subsequently deposited by



14. COMMON METHOD OF MAKING EMBANKMENT FOR SIDELONG GROUND

means of a double tip-head. The bank is subsequently widened if necessary by side tipping, forming that part of the embankment numbered 3.

High Embankments. When the embankment to be formed is very high, say 30 or 40 ft., it is usual to tip it in two loads; this is of special importance when the excavation is effected by the help of a steam navvy. This machine, when working in stiff ground, brings out the earth in very large lumps, and when the waggons are emptied at the tip-head the largest lumps are those which roll down to the bottom of the slope. The embankment therefore advances upon a layer of very large lumps of soil, having a bulk of perhaps as much as 20 cub. ft. The higher the bank the thicker will be this layer of large lumps, and unless they are broken up by hand as the embankment is made, the interstices left between them will be of considerable amount, and will cause the bank to contract and settle down for a long time after it is completed. By tipping the embankment at two different levels this disadvantage is very considerably diminished.



13. STEPS FOR EMBANKMENT

The Act of Tipping. The act of tipping or emptying the contents of the waggon over the tip-head requires some description. The waggon, as has been described, comes forward towards the tip-head with the velocity it has acquired from the engine before the latter has been detached. As it comes forward, a loop of chain is allowed to trail behind it, and immediately before the waggon reaches the tip this chain is caught by a large hook placed between the rails for that purpose. The hook is attached to a hawser, the other end of which is anchored into the bank some way behind the tip. The object of this is to prevent the waggon from falling over the slope of the tip, as it would be liable to do if it reached it with an excess of velocity. The waggon is ordinarily checked by a number of sleepers piled up at the very extremity of the railway. On coming against these, the catches which fasten the body of the waggon to the frame are knocked up by the men at the tip-head, and then the forward velocity of the waggon is sufficient to cause the body to fall over and empty its contents down the slope. The men then pull the body back to its former position and refasten the catches.

Returning the Waggon. Sometimes the waggons are designed so that the body falls back of itself to its old position after its contents have been tipped out. The men must detach the hook from the trailing chain, and connect the waggon with the engine, which then comes forward to draw it away. The sleepers piled up at the tip-head to check the waggon have wrought-iron handles at each end to enable the men to move them about easily. They have to be constantly moved as the work of the embankment advances, and are placed contiguously on the earth where the rails end, so that the waggon runs upon them as it leaves the rails. The waggon, of course, is not allowed to leave the rail unless it can be helped; but the embankment, it must be remembered, is constantly advancing, and the rails cannot be advanced in very short lengths. The sleepers are therefore laid in an upward curve, where the rails end, bringing the waggon to a stop, and causing it to run back again upon the rails. The sleepers are cut up very rapidly and destroyed by the flanges of the wheels, but they may be protected by iron.

Continued

Continued from page 2954

OUR WONDERFUL EYES

The Business of the Eye. Its Parts and Functions. Long and Short Sight. Faults of Vision. Imagination and Deception of the Eye

By Dr. C. W. SALEEBY

THE business of the eye is to appreciate light. It is necessary to remember, however, that various other kinds of stimulus may cause sensations of vision, as is indicated, for instance, in the phrase, "I will make you see stars." The technical name for normal vision is *emmetropia*. This word has a puzzling appearance, but the first two letters are really a modified form of the Greek *eu* which means "well." Emmetropia is defined as that state of the eye in which rays from a distant object are focussed upon the retina without any muscular effort within the eyeball, while the near point, so-called, which may be roughly defined as the point at which ordinary type may be comfortably read, is from 5 to 10 in. The child, as we have seen, has a more spherical lens than the adult, and its near point is at about 3 in.

How Light Strikes the Eye. In order, then, that these conditions may be observed, what must happen to the light as it passes through the eyeball? The rays of light from a distant object, such as a star (which, as usual, we assume to be parallel), are made to converge on passing through the cornea, which is obviously a convex lens. They converge still further on passing through the crystalline lens, and are brought to a focus upon the retina. The normal eye is such that the retina is approximately in the principal focus of the lens, or, at any rate, in the principal focus of the crystalline lens plus the cornea. Hence it is that all parallel rays (by which term, for practical purposes, we may include all rays from objects 20 yards or more away) are focussed upon the retina automatically or mechanically without muscular effort. The image, as we have elsewhere seen, is, of course, inverted. Now what happens when we look at an object which is relatively near and the rays from which are divergent? Obviously, the optical apparatus which was able to effect accurate focussing in the former case will not be of avail in this.

Accommodating the Eye to Circumstances. The mechanism by which the eye modifies itself is known as *accommodation*. Shut one eye and hold a pencil up in front of the other; then, instead of fixing the attention upon the pencil, turn the attention to the window that may be beyond the pencil, so as to observe, as distinctly as possible, whatever may be outside; the immediate consequence will be that the image of the pencil becomes blurred—an experimental proof of the fact which might have been arrived at deductively, that the eye cannot simultaneously focus parallel and divergent rays. In some fishes the mechanism of accommodation corresponds exactly to that which is employed in various familiar optical instruments—the distance between the lens and the retina is modified according to need. The other possible method (which is not open to, let us say, the photographer, whose lenses are made of glass) is to vary the convexity of the lens, and to do so in proportion to the need. This is what occurs in man. When we fix our attention upon a near object, we deliberately make the lens more convex or stronger, so that the rays, though divergent, are, so to speak, brought to a focus in time. If we did not so accommodate, they would be brought to a focus too late—that is to say, after reaching the retina. By various means of proof, which we need not here consider, it has been shown that what happens when we accommodate is a bulging forwards of the anterior surface of the lens, which, as we have seen, is less convex than the posterior surface when accommodation is not taking place.

The Ciliary Muscle. When the eye is at rest, accommodated for vision of distant objects, or *negatively accommodated*, as the phrase is, the ciliary muscle is not in action. *Positive accommodation* is the name applied to alteration in the shape of the lens when the ciliary muscle *is* thrown into action. It contracts in such a way as to allow the lens to bulge forwards. That is so because when the ciliary muscle is not in action the suspensory ligament of the lens is stretched and flattens the lens; but when the muscle acts it relaxes the suspensory ligament, and allows the elasticity of the lens to assert itself. Helmholtz and many other physicists have studied the mechanism of accommodation, and there has been a good deal of controversy about it, but the description we have given, following Helmholtz, is that generally accepted. If the ciliary muscle be very forcibly contracted, the suspensory ligament is so much relaxed that the lens actually falls a little. This may be shown by a simple experiment—placing two needles horizontally, one 10 in. and the other 40 in. from the eye, but both at the same level. If, now, one looks from the far needle to the near one, it seems to rise a little, the lens having fallen.

The Resting Eye. Since positive accommodation is a muscular act, it is fatiguing, whereas negative accommodation is restful. It is for this reason that it is good to have pictures of landscapes in a room, since, when one looks at them, the ciliary muscle is relaxed. The smallest physiological knowledge of what is implied in the contraction of a muscle will also teach that positive accommodation should not be made too continuous. It is a wise habit to close the eyes occasionally when reading or writing, not

merely because this affords an opportunity for thought, but also because it gives the ciliary muscle a little rest. We proceed immediately to discuss short-sightedness, but at this point we may note that the persistent use of the eye at near distances has a definite effect upon it. The structure of the eye tells us that the main use for which it is, so to speak, *intended*, is not the vision of near objects. Indeed, the finely symbolic truth has been recognised that the human eye is naturally focussed upon infinity—not upon the near and petty. Thus, while the eye contains within itself arrangements for the accurate vision of near objects for comparatively short spaces of time, it is bound to suffer if these arrangements are unduly exploited.

Civilisation and Sight. A measure of civilisation might almost be found in the degree in which it involves the use of the eye at short distances. The savage earns his meal by seeing the deer on the horizon and sending an arrow through it from afar. The citizen earns his at a desk. Thus the amount of positive accommodation is proportional to civilisation. Now, it is notorious that very many of us are nowadays short-sighted, and the Germans, the most studious people on earth, are the most short-sighted. This fact is not to be explained by the biological doctrine that the eyes of civilised man are becoming weak from overuse and that the weakness is transmitted. Such a doctrine contains at least two errors. The first is that acquired weakness of the eyes can be transmitted at all, and the second that the short-sighted eye is a weak eye. Set the savage to work all day beside a civilised man at something requiring positive accommodation, and one would soon learn which had the weaker eyes. The fact merely seems to be that the persistent contraction of the ciliary muscle actually alters the shape of the eye—as might quite well be expected. The eyeball, as a whole, probably has its shape altered, being made longer from back to front. It is such an eye that we usually call short-sighted. It follows that the short sight of the student is, after all, the result of an adaptation to the kind of work which he makes his eyes do. The more short-sighted his eye the less does he need to accommodate. Of this we shall see a further illustration when we come to consider long sight.

Short-sightedness. The technical name for short-sightedness is *myopia*, as distinguished from normal sightedness, or *emmetropia*. Since we have these two terms here, we may contrast with them the other two that resemble them—*hypermetropia* or long-sightedness and *presbyopia*, the particular form of long-sightedness due to the ageing of the eye. The defect of the short-sighted eye is that it is too long from front to back. The consequence is that parallel rays are brought to a focus too soon—at a point in front of the retina. Such an eye is said to be short-sighted because, in order to effect clear vision, an object must be brought near the eye. When this is done, the divergent rays from it are not brought to a focus too soon. This is why the short-sighted person holds a book near his eyes—in order to make the rays even more divergent than they are in any case. Sometimes the actual defect in the eye seems to be less an undue elongation from front to back than an increase in the curvature of the cornea.

The remedy for myopia is very simple. Lenses must be placed in front of the eye in such a fashion that parallel rays are artificially made divergent before they reach it. They will then not be brought to a focus too soon. Therefore, the short-sighted person uses spectacles with concave lenses, the measure of the concavity being proportional to his defect. As a rule, short-sightedness increases during the 'teens and for some time beyond. This lengthening of the eye from front to back may be put down to a normal tendency of its growth or to its introduction to long hours of positive accommodation, or to both factors; the last, perhaps, being the more important.

Long-sightedness. The simplest form of long-sightedness is that which we call *presbyopia*. It is a change in the eye which is not unwelcome to the short-sighted person, since it tends to neutralise his defect. We have already noted the age at which it occurs and its first symptom. The loss of elasticity of the lens is probably due to the same causes as its reduction in density. These two changes, between them, make positive accommodation difficult. In very old age the lens is so inelastic that, however much the suspensory ligament be relaxed by the effort of positive accommodation, the lens does not bulge at all.

The second form of long-sightedness, *hypermetropia*, is due to the opposite defect to that which causes myopia. Either the cornea is too flat or, as is the rule, the eyeball is too short from front to back, the consequence being that parallel rays are not focussed upon the retina in time. In order to effect this focussing, positive accommodation is necessary. Hence, positive accommodation is always necessary with the hypermetropic eye, whereas it is not in the presbyopic eye. It follows that the ciliary muscle is very much over-worked in, for instance, long-sighted children, the commonest consequence being headache. The difference between hypermetropia and presbyopia can be demonstrated by the use of the drug called atropine, which paralyses the ciliary muscle. If this be brought to bear upon a presbyopic eye, near objects are blurred, but not distant objects. But all objects are blurred for the hypermetropic eye which has been placed under the influence of atropine, since such an eye needs the use of its ciliary muscle for the proper focussing both of parallel and of divergent rays.

Plainly, the reason why the long-sighted person holds print at arm's length from the eye, is that he thereby makes the divergence of the rays as slight as possible.

Obviously, the manner in which to correct a defect which consists in not focussing the rays in time is to add a converging or convex lens

to those which the eye already possesses but which are insufficient to meet the demands made by the nearness of its retina to its crystalline lens. Again, the convexity must be proportioned to the shortness, that is to say, the long-sightedness, of the eye. The artificial lenses must be made extremely convex in cases where, owing to cataract, the crystalline lens of the eye has had to be removed altogether.

"Near Point" and "Far Point" of Sight. By the far point, or *punctum remotum*, is meant the most distant point seen without accommodation. There is a good deal of confusion in the use of these terms, however, and often the term *far point* is used in other ways. At any rate, the far point is brought nearer for the short-sighted eye, while for the long-sighted eye there is no far point at all—accommodation being always necessary. On the other hand, there is a limit to accommodation, and this is indicated by the near point, or *punctum proximum*. In the presbyopic eye the near point is removed, while the far point is unaffected. In the hypermetropic eye, both near point and far point are made more distant, while in the myopic eye, both are nearer. An extremely short-sighted person may be seen reading at distances so close that the print would be absolutely illegible to an emmetropic eye—being within its near point.

The cornea very frequently offers a special complexity to the act of vision by reason of its curvature not being equal in all directions. The resulting defect of vision is known as *astigmatism*. Such an eye cannot clearly focus at one and the same time the two limbs, horizontal and vertical, of a cross. The commonest form of this defect is that in which the cornea is more convex in the vertical direction than in the horizontal—in other words, the eye is short-sighted, or is more short-sighted, for the vertical limb of the cross than for the horizontal. Whatever the particular angle be, glasses can, however, be ground so as to compensate for the defect. If one suffers from the rare defect of pure astigmatism, one merely requires cylindrical lenses placed at the necessary angle. If, however, as is much more frequently the case, short-sightedness and astigmatism go together, compound lenses have to be ground so as to correct both defects. It is obvious that the curvature of the cylindrical lenses, added to that of the least convex meridian of the cornea, will make its focal length equal to that of the maximum meridian.

The Constant Defects of the Eye. There are certain constant defects of the eye of which Helmholtz was thinking when he made the remark which we have elsewhere quoted. We may note them without in any degree detracting from the wonder and admiration which the amazing powers of this organ must surely arouse in us. Charles Darwin, who showed how the evolution of the eye may be explained by natural processes, said that " he never could think of the eye without a cold shudder," so insuperable at first seemed the difficulties of explaining its wonderful construction on his principles.

The defect of spherical aberration is not very serious, and is corrected, to a very large extent, in several ways. First, as we have already seen, the iris cuts off the outermost rays, and cuts off more of them when the rays are more divergent, and the consequences of not doing so would be more marked. Secondly, the curvatures of the two surfaces of the lens are not the same, but tend to correct one another in this respect. Thirdly, the lens is denser in its centre, as we have already seen, so that its refractive power is less at its circumference; and fourthly, the curvature of the cornea is not really spherical but is such that rays furthest from the axis are less deviated than they would be if the curvature were spherical.

The Eye and Colour. The eye is also somewhat defective on the score of chromatic aberration, though not nearly so much as it would be were it not that, as we have seen, some measure of achromatism is obtained by the use of media of dissimilar constitution. Says Prof. M'Kendrick: " . . . If, however, we look at a candle flame through a bit of cobalt blue glass, which transmits only the red and blue rays, the flame may appear violet surrounded by blue, or blue surrounded by violet, according as we have accommodated the eye for different distances. Red surfaces always appear nearer than violet surfaces situated in the same plane, because the eye has to be accommodated more for the red than for the violet, and consequently we imagine them to be nearer. Again, if we contemplate red letters or designs on a violet ground, the eye soon becomes fatigued, and the designs may appear to move."

The Eye may See Itself. If we merely consider the fact that the part of the eye which actually sees is practically the hindmost part, being not merely the retina, or curtain at the back of the eye, but practically the deepest layer of that curtain, we shall realise that, under certain conditions, the eye may see itself or parts of itself. It has already been noted that white blood corpuscles, wandering about in the vitreous humour, may cast appreciable shadows upon the retina. Shadows more serious, because permanent, may also be cast by, for instance, scars upon the cornea. The remarkable fact about all such phenomena is that the mind projects them into external space so that they are referred to the outside world; whereas, in reality, they exist in the eye itself. Far and away the most remarkable of these are due to the eye's perception, by means of the ninth or all but the deepest layer of the retina, of objects normal or abnormal, in the eight layers of the retina through which all light has to pass before it reaches the percipient layer. Ignoring perception of opaque spots, which are abnormal in any part of the retina, we may consider the remarkable fact that, under certain conditions, the eye may become conscious of the blood-vessels that normally lie in the retina. If a strong beam of light be thrown upon the edge

of the sclerotic, or white of the eye, one is conscious of a curiously branched appearance which technically goes by the name of *Purkinje's figures*, and which is none other than an image of the retinal blood-vessels. Another experiment also suffices to reveal to the eye its own retinal blood-vessels. This consists of "looking at a strong light through a minute aperture, in front of which a rapid to-and-fro movement is made."

Can we "See" Canals on Mars? These experiments are of interest to the physiologist because they prove to him that it is practically the deepest layer of the retina, the last to be reached by the light, which is the really sensitive and essential part of it. But they are also of extraordinary interest to us as students of physics.

The reader is familiar with the so-called canals of Mars, which have given rise to so much controversy since their discovery by Schiaparelli. Doubtless, also, he has heard of what are called the N rays, asserted to be a new kind of ethereal vibrations and believed to have been discovered a year or two ago by M. Blondlot, of the University of Nancy, in France, from the first letter of which he derived their name. It is not our business here to discuss the canals of Mars beyond merely noting what the reader has doubtless heard, that their existence as an objective fact—whatever its interpretation—has lately been proved by the camera. They have been photographed. As for the N rays, to which we may have space to return, their case remains dubious. But the actual facts as to these two cases are not the present point.

Does the Eye See What is not There? The interesting matter for us is that the reality of both of these appearances has been questioned, and quite legitimately questioned, on grounds suggested by the physics of the eye. The common alternative, with which we are all familiar, as regards any appearance, is simply this—Does it correspond to a real existence in the outside world, or is it due to imagination? This applies, let us say, to the case of a ghost. Was there something "really there" which gave rise to the ghostly appearance, or was it a hallucination? To very few people has it occurred that there is a third possibility in certain cases. It may be that the eye really sees something which is really *somewhere* but is not really *there*. It is within the eye itself, but so persistently does the mind refer sensations of vision to the exterior world that the eye is deceived.

For instance, in the case of the canals of Mars, experiments made by a distinguished English astronomer, Mr. Maunder, showed that, whether or not these really exist, it is possible under certain conditions to produce appearances which may be mistaken for them. When schoolboys were set at sufficient distances from blank maps of Mars, on which they were told that canals were to be seen, very faintly marked, if only they looked carefully enough, they drew appearances which strongly suggested those figured by Schiaparelli. Other explanations are possible, perhaps, but the likeliest is that, by excessive straining, these boys had gained faint impressions of the blood-vessels in their own retinæ.

Imagination and Sight. Similarly, it was argued in the case of the astronomer, it entails considerable strain to look through a telescope for any length of time, and the argument was that the strained eye became hypersensitive so as to see and attribute to Mars images of the blood-vessels within itself. A similar train of argument applies to the N rays. The fact that in the case of the canals of Mars, at any rate, the objective character of the appearance has now been proved by other means, does not in the least detract from the importance of recognising the possibility of this error. Chiefly, perhaps, it is important from the point of view of the psychologist, but the physicist has to recognise it if he is not to make serious errors. After this explanation the reader will distinguish once and for all between (1) the results of imagination, so-called; (2) the results of vision of what is really external and appears to be so; and (3) the results of vision of what is really within the eye but, in consequence of the overwhelming preponderance of experience, is thought to be external.

The Proper Light of the Retina. In this phrase, as in a very large number of other scientific and philosophic phrases, the word *proper* has its *proper* meaning, with which the reader should be familiar. It is, of course, derived from the Latin *proprius*, and it means *own* or *proper to*. In defining the term we cannot do better than quote the words of Professor M'Kendrick, who is one of the chief students of the subject. He says: "The visual field, even when the eyelids are closed in a dark room, is not absolutely dark. There is a sensation of faint luminosity which may at one moment be brighter than at another. This is often termed the *proper light of the retina*, and it indicates a certain condition of molecular activity, even in darkness."

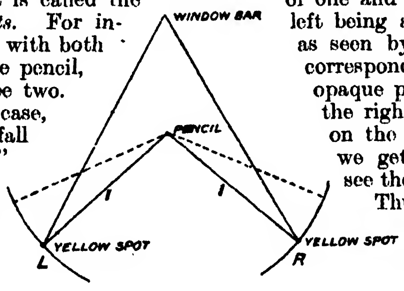
The recognition of this proper light of the retina will suffice to remind us of the all-important distinction between *light* and *vision*. On the one hand, there is abundance of light which cannot cause vision—that is to say, ethereal vibration just outside the octave which we happen to be able to see; while, on the other hand, there may be vision which is not caused by light.

The Use of Two Eyes. Constantly, as in the last paragraph, we find ourselves led to consider the retina—the ultimate fact of the eye—but we must leave this subject to the last. Meanwhile, we must note in its place a fact which has been carefully discussed in the course on Psychology. It was there shown that vision with two eyes, or binocular vision, gives us our impressions of depth or perspective or solidity. In discussing sound, we saw that the only value of having two ears, apart from having another to fall back upon if one be injured, is that they help us to appreciate the *direction* of sound. The possession of two eyes, however, gives us far more, since it gives an entirely new and distinct quality to our vision. This is absolutely true, notwithstanding the fact that long experience

with two eyes and with the other senses may enable us to obtain perceptions of depth as well as height and breadth, even with one eye only. If it is desired to prove how little value experience has when it comes to a test, let one try to thread a needle at a little distance with one eye shut.

If both eyes be equally strong, the perception which they give is not identical with the perception of either eye alone, but it is almost invariably the rule that one eye is stronger than the other, and that it is *its* image which we perceive.

When One Thing Looks Like Two. But let us consider what simultaneous vision with two eyes requires. Compare the case of trying to look at one's own nose with that of looking at a star. In the latter case there is practically no "optic angle"—that is to say, the angle formed by lines from the object through the centre of each of the two eyes. On the other hand, in looking at one's own nose there is a very large optic angle. The contrast between the two cases will suffice to show the extreme complexity of the arrangements which are necessary in order to enable us to obtain a simple image from two eyes. This possibility is explained by what is called the *theory of corresponding points*. For instance, if we look at a pencil with both eyes at once, we only see one pencil, but if we look past it we see two. This implies that, in the first case, the two images of the pencil fall upon "corresponding points" in the two eyes—*viz.*, the two yellow spots. But when we look past the pencil at something beyond it, the eyes which were formerly slightly converged or squinting, look more forwards and parallel with each other. The consequence is that the images from the pencil do not fall upon points of the two retinæ which correspond or are accustomed to act together. The accompanying diagram will readily explain this. The lines marked 1 indicate the manner in which, in the first position, the rays from the pencil fall upon corresponding points in the two eyes. But in the second position, when the eyes are looking at the window bar, the rays from the pencil will fall in the fashion of the dotted lines—that is to say, upon the outer parts of the two retinæ, which are not accustomed to act together. On the contrary, the left halves and the right halves of the two retinæ contain corresponding points.



The Eye's Complex System of Muscles. It follows from these considerations that the simultaneous movements of the two eyeballs in binocular vision, in order that two images of any object may fall upon the corresponding points in the two retinæ and may thus be perceived as one, require the most complicated nervous arrangements. In order to carry them out, each eyeball has six muscles, each set of six being supplied by three nerves, and the whole being controlled from a centre in the brain. This co-ordinated movement is the most complicated known. It would require a page to describe its complexity in such a case as, for instance, looking at a pencil held close in front of the two eyes and then following it with both eyes while it passes to right or left. In such a case the eyes are convergent all the time, and as they pass to one side or the other, the one eye has to rotate through a much wider angle than its fellow in order that single perception may still result. The reader can easily draw for himself a diagram which will show this. Its successful accomplishment is one of the marvels of nerve physiology. Some kind of explanation of this possibility is furnished by the fact that while we can move one eyelid, we cannot move one eye. In other words, the movements of the two eyeballs are simultaneously controlled from one centre and are so interdependent that they cannot be made independent.

How the Eye is Deceived. The student of the course on Chemistry is already acquainted with the stereoscope, or *solid seer.* This is simply an apparatus by which one places side by side two photographs or drawings of one and the same object; that on the left being a representation of the object as seen by the left eye, and the right corresponding. If now we place an opaque partition in such a fashion that the right eye can see only the view on the right and the left similarly, we get a stereoscopic percept—we see the thing in relief.

Thus the eye is, of course, deceived, and there are many and familiar other means by which it can be shown how the eye is at the mercy of many external circumstances. Take, for instance, judgments of size. We have already seen that an object at twice the focal length of a lens has an image of the same size. At less than twice the focal length the image is enlarged; at more than twice the focal length it is smaller. The images of all the objects we see, except by the aid of the microscope, are smaller than the actual objects. Nevertheless, the eye is, so to speak, deceived into thinking that it sees things as large as they are. Similarly, it is deceived into thinking that it sees things upright, whereas all retinal images are inverted.

These, of course, are uses of the word *deceive* which we have deliberately made unusual. A more common use of the word may be employed in noting other visual judgments. Everyone is familiar with pairs of diagrams, such as those which we here reproduce, wherein two lines of exactly the same length are made to appear very unequal, merely in consequence of the way in which other lines are drawn from them.

Continued

INSPIRATION

The Limitations of Mental Energy and the Value of Passiveness. The Unconscious Working of the Mind. Food for Mental Inspiration

Continued from page 2838

By HAROLD BEGBIE

NOTHING is of more vital importance to the success of the student's schemes and plans than the recognition of the limitation of mental energy.

By practice we can increase our power of hard reading, by an effort of will we can intensify and extend our faculty of attention, but there comes a time when the mind—the physical organism of the brain—rebels against such enforced labour, and all our painful reading is in vain.

> The eye it cannot choose but see,
> We cannot bid the ear be still ;
> Our bodies feel, where'er they be,
> Against or with our will.
>
> Nor less I deem that there are powers
> Which of themselves our minds impress ;
> That we can feed this mind of ours
> In a wise passiveness.
>
> Think you, mid all this mighty sum
> Of things for ever speaking,
> That nothing of itself will come,
> But we must still be seeking ?

The value of this period of wise passiveness can scarcely be exaggerated. Wordsworth regards it as a time when we may feed our minds, and no doubt he is right ; but it is a time above all others when our minds can feed us. The consciousness of the individual in moments of great quiet and extreme passiveness will receive ideas and images of which either it had hitherto never been cognisant or cognisant only unintelligently.

Subconscious Activity. One of the mental processes of which we know least, but of which we are, perhaps, more assured than of any other, is the subconscious germination of ideas. It is the most perplexing, the most interesting, and the most suggestive of all the mental processes. There is a department of our mental machinery which takes over the ideas we toss to it or let slip from our fingers—even, too, the ideas which creep in unknown to us between the gates of consciousness—and, receiving them, does not merely hold them and retain them as a sensitive plate holds and retains the picture flashed upon it through the lens of a camera, but, rather, receives those ideas as the earth receives a seed or as an incubator receives an egg, and, all unconsciously to ourselves, broods upon those ideas and transforms them into other forms and fresh energies and powers.

Professor William James has said that we learn to swim in winter and to skate in summer, by which he means that having tried to skate through a single winter, and having progressed but indifferently, when we come to renew our efforts with the following winter we find to our amazement that we begin, not where we left off, but in advance of everything that we had ever attempted before. A boy who has once learnt to swim never forgets the art, and, though practice be necessary to make him a good swimmer, and training to get him into " the pink of condition," still he is always a potentially better swimmer every time he enters the water, even though years elapse between his experiences.

Its Bearing on Study. It is to this secret working of the mind that the educator must bring his intelligence in considering his plan of conduct. Periods of rest from concentrated effort are not a passive good to him, they are an active good. He must cultivate them as assiduously as he cultivates concentration or will-power. He must accustom himself to remaining quiet and receiving from his subconscious self, or, as F. W. H. Myers would say, from his subliminal consciousness, more vivid images than his purely intuitive faculty can create or his most energetic reflection can supply. It is to these images he must look for his originality. The ideas presented to him " in a wise passiveness " are the fruit of his own personality, the colour of his own individuality, the express image of his own spirit. Originally he received the seed from another mind, or from the universal mind whence all intuitions proceed, but as they present themselves to him now they are not the seed but the flower from the soil of his own soul. Fragrant and life-giving herbs they may be, or poisonous and deadly weeds—whichever they are, they will be the fruit of his own growing. Whatsoever he sows that also shall he reap.

Let the educator, then, be warned, first, against what Huxley called " the educational abomination of desolation "—book-gluttony and lesson-bibbing. Even the hardest-worked of us all, he says, if he has to deal with anything above mere details, will do well, now and again, to let his brains lie fallow for a space. " *The next crop of thought will certainly be all the fuller in the ear, and the weeds fewer.*"

The Value of Passiveness. And, in the second place, the student must be warned against regarding periods of passiveness as wasted time. It is easier to frighten a man away from book-gluttony and lesson-bibbing than to convince him of the fruitfulness of a wise passiveness. But we hope to show that far from being a wasted time, a time of wise passiveness is just that period in which inspiration can best do its work—inspiration which is the flame of originality and the fire of genius.

Genius is defined by Myers in the famous third chapter of " Human Personality " as a power of utilising a wider range than other men can

utilise of faculties in some degree innate in all, and an "inspiration of genius" as in truth a subliminal uprush, an emergence into the current of ideas which he has not consciously originated, but which have shaped themselves beyond his will, in profounder regions of his being.

R. L. Stevenson used to lie abed before sleeptime thinking of his stories, setting, as he said, "the brownies" to do his work for him. The part of the work done in sleep, he said, is the brownies' part beyond contention; "but that which is done when I am up and about is by no means necessarily mine, since all goes to show the brownies have a hand in it even then."

The Secret Work of the Mind. Beyond contention, indeed, is the fact that our brains work for us when we are idle, that our thoughts move faster when we are not behind them flogging their jaded energies with the whip of concentration. When Huxley said that the crop of thought, after a time of fallow, would certainly be all the fuller in the ear, and the weeds fewer, he stated what his readers believed to be a truth, but a truth the significance of which neither the people who subscribed to it nor the brilliant man of science himself thoroughly apprehended. Huxley was not a profound psychologist, and he was so devoted a physicist that he did not even stop to ask why a brain should know more after a period of rest than it knew before. Myers' great work was not then published, and, indeed, it is only of quite recent time that evidence has been accumulated sufficient to justify the thesis of that work. It is now, we advance, beyond contention that the mind's inspiration is received from the invisible germination of ideas in a "department" of the mind below the threshold of consciousness. It is proved, by experiments in hypnotism, and by everyday experience, where carefully observed, that the mind works in secret in bringing to perfection the ideas and images received by it with or without the knowledge of the consciousness.

Food for Mental Inspiration. This being so, the educator must inquire in which direction his talents lead him, and be careful to work as far as possible in that direction, since it is on that road more than on any other that inspiration is likely to shine for his feet. A man with a natural bias towards machinery should not hope to experience a musical inspiration or a military inspiration. He should not—if he is bent on pushing his fortunes—make a study of literature or a study of commerce. He should read deeply about machinery, and should converse with men profoundly conversant with machinery, and so in his moods of passiveness he will be likely to receive inspiration in the invention of machinery. To feed the mind on that which it demands—provided always the taste is sane and healthy——is to provide it with the material for inspiration.

It must always be remembered that these subliminal uprushes, or, as we say in the language of the street, these happy thoughts, come almost invariably in moments when the consciousness is least busy. The man of iron will is seldom a creative genius, the brilliant administrator is seldom a man of ideas. The consciousness is kept so busy by these energetic minds that the brain never obtains a hearing. They may, indeed, become so immersed in their work that consciousness is practically in abeyance —that is to say, the consciousness is so intent as to shut off all the appeals which reach it through the avenues of sense—in which case the happy thought, the bright idea, may come to them. There are authors whose inspirations come during the moment of composition—whence, they know not, nor how; they have not dreamed the idea beforehand, they have not received it in periods of a wise passiveness, it has come to them when in the midst of work; their consciousness has been so intent that the striking of a clock has not reached their ears nor the opening of a door attracted their attention.

The Spontaneity of Inspiration. In this case, if we thoroughly understood the mechanism of the brain, we should probably find that consciousness was as much removed by its very intensity of concentration as it is removed in the hypnotic trance by gazing fixedly on a bright light. One thing at least is certain, and on this the educator should fasten his apprehension—no amount of brain cudgelling will ever bring forth a flash of genius. Not by any amount of hammering on the anvil of thought does the spark fly for which, like the scholar-gipsy, we all wait—the spark from heaven. Indeed, it is by striving and wrestling and overlonging that we drive it away from us, keep it afar off. It comes like a thief in the night, it comes when we are least prepared for it, it comes to us with a sudden uprush of vitality which makes us think that till then we have never seen nor heard nor lived. To receive it we must accustom our minds to periods of abstraction, but not periods of enforced and difficultly continued abstraction, not periods where effort and energy play any part. It requires no particular posture of repose, no studied and preconsidered arrangement of environment. Walking, or eating, or on the high seas, the idea may come for which we are waiting. All that is necessary is the gradual cultivation of ease in our consciousness, the occasional checking of that busybody and inquisitive spirit which keeps the consciousness of some unhappy people in a perpetual flurry and excitement. A man of science and a great inventor has said that his life is so busy that he has no time to receive inspiration except when he is dressing. Some people have their consciousness more vivid and alert before the mirror than in any other place, and for them ideas are not likely to come at such a time, if ever at all. But it is just in periods of this kind—simple periods in the day when we are doing things which have become more or less automatic with us—that we are most likely to receive the harvest of our hopes and labours.

Continued

A LIMITED COMPANY'S ACCOUNTS

Group 7
CLERKSHIP
22

Continued from page 2982

Formation of Company. Capital. Shares. Prospectus. Register of Members. Purchase of a Business

By J. F. G. PRICE

A LARGE and constantly increasing proportion of the business of the country is carried on by what are known as limited companies. Indeed, it is scarcely an exaggeration to say that the giant strides made by our commerce in the last half century would not have been possible without the assistance derived by private enterprise from the co-operation of the small capitalist by means of the facilities afforded by limited liability companies.

Firms and Limited Companies. Before we can proceed to deal with the accounts of limited companies, it is necessary that we should know something of what a limited company is. It has been seen that a partnership is a combination of two or more persons who have united their resources for the purpose of jointly carrying on a business for their common benefit. They are jointly and individually liable for the debts of the firm, and in the event of failure, are bound to contribute to the full extent of their private property, if necessary, to discharge the firm's indebtedness to outside persons.

In the case of a limited company, the proprietors, who are called shareholders, are only liable to be called upon to pay the debts of the company to the extent of the amount they agreed to contribute when they first joined the concern. In other words, their liability is limited, and the extent of the limitation is fixed by the shareholders themselves when they determine to become members of the company.

Memorandum of Association. A company is a number of persons combined into one body by law, so that the company has a distinct personality apart from the persons who compose it. It must consist of at least seven members, and if at any time the number should fall below seven, the company can be wound up. Every company must be registered at Somerset House with the Registrar of Joint Stock Companies, and the first step to be taken is for at least seven persons to sign a document known as the memorandum of association, which must contain certain particulars. Those particulars are: (1) the full name of the company in which "limited" must be the last word; (2) the part of the United Kingdom in which the registered office will be situated; (3) the objects of the company, which are stated very fully; (4) a statement that the liability of the members is limited; and (5) the amount of the capital of the company and the manner in which it is divided into shares. Each of the signatories to this document must agree to take at least one share in the company.

Articles of Association. With the memorandum it is usual to lodge a further document known as the articles of association, which contains the regulations for the carrying on of the company. The articles make provision for calls on shares, transfers of shares, meetings of the company, votes of members, accounts, audit, winding up, etc. If articles of association are not lodged the company is regulated by a model set provided by the Companies Act, 1862 [Table A]. It would manifestly be impossible for the business of a company to be conducted by the shareholders as a body, and the work is therefore delegated to a small number of persons who are called the directors. They are frequently appointed by the articles of association, which also regulate their powers, qualification, retirement, etc.

The memorandum and the articles (if any), and a separate statement of the capital, have to be left with the registrar, together with a declaration, usually made by a solicitor, that all the requirements of the Companies Acts have been complied with. Certain stamp duties have to be paid, increasing with the amount of the capital, and if the documents are regular, the registrar issues a certificate that the company has been incorporated.

The Company's Capital. Mention has been made of the company's capital and of the shares into which it is divided. Both these terms require further explanation, for the word capital has several different meanings in connection with a company, according to the sense in which it is employed, while there are various kinds of shares, each having different rights. The capital which is named in the memorandum of association is known as the *nominal capital* of the company, and is the maximum amount of shares the company is allowed to issue. The amount of the shares which the company has actually issued to applicants is known as the *subscribed and issued capital.* The amount which the shareholders have been required to pay upon the shares issued is the *called-up capital,* and the amount received by the company on the shares is the *paid-up capital.*

Classes of Shares. The nominal capital of a company is divided into a number of parts of fixed amount called *shares,* each of which has a distinctive number given to it. When there is only one class of shares they are called ordinary shares. When the capital is divided into two classes, they are usually *preference* and *ordinary* shares, the former entitling the holders to participate in the profits of the undertaking to a certain fixed limit before any distribution is

made to the ordinary shareholders. The limit is fixed by way of a percentage upon the amount paid up on the shares, which are known as five per cent. or six per cent. preference shares, or as the case may be.

When the preference shares have received their percentage, the ordinary shareholders are entitled to the remainder of the profits, provided there are no other classes of shares ranking behind them. Distributions may be made to the shareholders only out of profits actually earned, and such distributions are called dividends. There is sometimes a further class of shares, entitled *founders'* or *deferred* shares, which are usually few in number, and entitle the holders to a fixed proportion of the profits remaining, after paying a dividend at a certain rate upon the ordinary shares—frequently ten per cent.

The Prospectus. Many companies are formed for the purpose of purchasing as going concerns businesses which have previously been carried on by firms or individuals, and in order that the money required to pay the purchase price may be obtained, an invitation is generally made to the public to take shares in the new company. The invitation is contained in a document known as a *prospectus*, which has to be filed with the registrar. If the company is a large one, the prospectus is advertised in the Press, as well as being circulated by post to probable investors. It sets out the object with which the company has been formed, and, for the purpose of enabling recipients to form an opinion of the prospects of future success, information is given as to the value of the property to be taken over and as to the profits which have been earned in the past by the old proprietors. This information is usually given in the shape of valuations by experts, and certificates of profits by public accountants.

The prospectus further states the manner in which the shares will have to be paid for, which is usually a certain amount per share on applying for them, another amount on allotment, and further sums at stated intervals, until the full amount of the share has been paid. Part of the full amount may be left to be called up by the directors as the business of the company may require. The names and addresses of the officers of the company are also given, including those of the directors, bankers, auditors, solicitors, brokers, and secretary. Certain other particulars have to be given in order to comply with the requirements of the Companies Act, 1900; but although these are of the utmost importance from the legal point of view, they do not require further mention here.

Application and Allotment. Enclosed in the prospectus is a form of application for shares, which has to be filled in and signed by the intending investor. He then has to forward it to the company's bankers, with a remittance for the amount stated in the prospectus as being payable on the shares. The money will be retained by the banker, and the application form sent on by him to the company. The secretary makes a list of the applications, showing the number of shares applied for, and a meeting of the directors is held to consider them. It is necessary for the directors to state in the prospectus the number of shares which must be applied for before they will issue any to the public, or, as it is termed, go to allotment.

If application has been received for the minimum number of shares, the directors proceed to allot them to the applicants in accordance with their applications—*i.e.*, they pass a resolution apportioning to each applicant the number of shares for which he has applied. In order to make the allotment binding upon the shareholder, a notice called a letter of allotment is sent to each applicant, stating the terms upon which the allotment has been made, and requiring him to pay the further amount now due upon his shares. As the dates arrive upon which further instalments are payable, applications are made by the company to the shareholders for payment until either the full amount of the shares or the amount mentioned in the prospectus as payable within a given time has been called up.

Entries in the Company's Books. Having now described the machinery by which the capital of a limited company is brought into being, it is necessary to explain the entries requisite for recording the various transactions in the company's books. In the case of an individual there is, of course, no obligation from himself to the business to provide the money he actually puts in as capital, and if he decides, upon reflection, not to start the business or invest his money, he is not bound to do so.

But in the case of an applicant for shares, the position is different. As soon as the company has notified its acceptance of his offer to take shares, he becomes bound to the company for the full amount of the shares allotted to him. As we have seen, he may not have to pay the full amount at once, but the company has the right to call upon him to pay at some time, and he is at once a debtor for the amount payable on the shares in respect of the instalments due on application and allotment. Entries are therefore made, debiting the shareholders with the amount due from them on application and allotment, and crediting accounts opened in the general ledger, entitled application account and allotment account.

Opening the Capital Account. Separate accounts are not opened for each shareholder in the general ledger. A distinct book is kept for the accounts of the individual shareholders, which is entitled the share ledger, and is generally combined with another book which the company is required by law to keep—*viz.*, the register of members. The form of the combined book will be shown later; at present we will follow the entries to be made in the company's general accounts. Let us suppose that a company has received applications for, and has allotted, 1,000 shares of £10 each, upon which £1 per share is payable on application, £2 per share on allotment, and £2 per share one month after allotment, the remaining £5 per share not being required at present. The entries

necessary in the company's books are first passed through the journal preparatory to being recorded in the ledger, and would be as under:

June 1	Sundry Shareholders	Dr.	1,000	0	0			
	To Application Account							
	For £1 per share, payable on application, for 1,000 shares of £10 each							
June 7	Sundry Shareholders	Dr.	2,000	0	0			
	To Allotment Account					2,000	0	0
	For amount payable on allotment for 1,000 shares at £2 per share							
July 7	Sundry Shareholders	Dr.	2,000	0	0			
	To First Call Account					2,000	0	0
	For amount payable one month after allotment, on 1,000 shares at £2 per share							

The entries would be posted to accounts in the ledger in the usual way.

The company will have received the full amount of the application money through its bankers; we will assume further that all the allotment money has been received, and that £1,900 of the first call is also received. These amounts will be entered on the debit side of the cash book and posted to the credit side of the sundry shareholders' account. Entries are then made in the journal closing the application, allotment, and first call accounts by transferring the balances to an account called the share capital account, which is the true capital account of the company and remains open in the ledger throughout the company's existence.

As a result of these various journal and cash book entries the accounts in the ledger will appear as shown below.

The balance to the credit of the share capital account represents the amount for the time being called up on the shares, while the debit balance on the sundry shareholders' account is the amount unpaid in respect of the calls which have been made.

Register of Members and Share Ledger. It is now necessary to ascertain how the accounts of the individual shareholders are dealt with. As in the case of a private partnership, each proprietor has a capital account of his own, although, as a rule, the book in which the accounts are kept is treated as a statistical book and not as a book of account. It is found convenient to combine the register of members, containing certain particulars and which the company is required by law to keep, with the share ledger containing the cash account of each member in relation to his share holding. Every member is debited with the respective amounts payable on his shares and credited with all sums he pays in respect thereof. The register shows not only the number of shares he acquires and disposes of, but also their distinctive numbers. The totals of the amounts debited to the individual shareholders must naturally agree with the amounts debited to the sundry shareholders' account in the general ledger, and the totals of the sums credited as paid will agree with the credits on that account. This explanation will enable the reader to understand the entries appearing in the form shown on the next page.

Dr. SUNDRY SHAREHOLDERS' ACCOUNT Cr.

June 1	To Application Account..	1,000	0	0		By Cash (posted in daily or weekly totals from Cash Book)	1,000	0	0
June 7	,, Allotment Account ..	2,000	0	0		,, do. do. ..	2,000	0	0
July 7	,, First Call Account ..	2,000	0	0		,, do. do. ..	1,900	0	0

Dr. APPLICATION ACCOUNT Cr.

July 31	To Share Capital Account	1,000	0	0	June 1	By Sundry Shareholders..	1,000	0	0

Dr. ALLOTMENT ACCOUNT Cr.

July 31	To Share Capital Account	2,000	0	0	June 7	By Sundry Shareholders..	2,000	0	0

Dr. FIRST CALL ACCOUNT Cr.

July 31	To Share Capital Account	2,000	0	0	July 7	By Sundry Shareholders..	2,000	0	0

Dr. SHARE CAPITAL ACCOUNT Cr.

					July 31	By Application Account..	1,000	0	0
						,, Allotment ,, ..	2,000	0	0
						,, First Call ,, ..	2,000	0	0

REGISTER OF MEMBERS AND SHARE LEDGER

Name: JOHN SMITH.
Address: 100, New Street, Oldtown. Occupation: Merchant.

Date of becoming a member: 7th June, 1906.
Date of ceasing to be a member:

SHARE ACCOUNT													CASH ACCOUNT								
SHARES ACQUIRED.						SHARES TRANSFERRED.							Dr. AMOUNTS PAYABLE.					CASH PAID.			Cr.
Date.	No. of Allotment or Transfer.	Tranferor's Folio.	No. of Shares acquired.	Distinctive Numbers. From	Distinctive Numbers. To	Date.	Transfer No.	Transferee's Folio.	No. of Shares transferred.	Distinctive Numbers. From	Distinctive Numbers. To	Balance of Shares held	Date.	Particulars.	Amount per Share	Fo.	Amount.	Date.	Particulars.	Fo.	Amount.
1906. June 7	18		100	751	850	1906. Aug. 20	6	87	50	751	800	50	June 1	To Application..	£ 1		100 0 0	June 1	By Cash Application	C.B. 1	100 0 0
													June 7	,, Allotment	2		200 0 0	,, 8	,, Cash Allotment.	10	200 0 0
													July 7	,, First Call	2		200 0 0	July 9	,, Cash First Call ..	25	200 0 0

Subject to the articles of association, members are allowed to transfer their shares, should they at any time wish to do so, and it may be pointed out that this is a further difference between limited companies and partnerships, for in the latter a member is only allowed to transfer his share in the business with the consent of his partners.

Forfeiture of Shares. A provision is usually inserted in the articles of association giving the directors power to forfeit any shares upon which calls are in arrear. Notice must be given to the shareholder of the intention to forfeit, and, if he fails to pay, a resolution may be passed declaring his shares forfeited, whereupon he will cease to have any further interest in them. The company will retain the amount paid up on the shares, and will be at liberty to issue them afresh to any other person willing to take them, who may be required at the discretion of the directors to pay either the full amount or the balance unpaid by the original shareholder.

Upon the shares being forfeited, entries would be made in the general ledger giving effect to the operation by reducing the amount to the credit of the capital account to the extent of the sum called up on the shares forfeited, and by writing off from the sundry shareholders' account the balance due and unpaid on the shares. The journal entries giving effect to the transaction would be as given at the head of the next page, and would be posted to the respective ledger accounts in the usual way.

Purchase of a Business. The entries necessary to record the taking over by a company of the assets and liabilities of a vendor follow the usual lines in opening the books of an ordinary business. Accounts are opened for the assets and debited with their book values, the vendor being credited with the total. The liabilities taken over by the company are then credited to their respective accounts and the vendor is debited with the total. The result is that the books show all the assets acquired and all the liabilities assumed by the company, while the balance of the vendor's account represents the net amount payable to him for his business. If he is paid the whole amount in cash he is debited as the payments are made to him; cash, of course, being credited.

The vendor sometimes agrees to take part of his purchase price in shares of the company, which are issued to him credited as being paid up—*i.e.*, the company's liability to him for his property is set off against his liability to the company on the shares to the extent of the nominal value of the latter. When payment is made in this way the vendor is debited with the nominal value of the shares and the share capital account is credited. The result will be the closing of his account, as the payments in cash or shares being for the difference due to him will exactly balance the account. An account is opened for him in the share ledger, in which he will be shown as the holder of the shares allotted to him, credited with the full amount paid up.

Dec. 31	Share Capital Account.. .. .. Dr.	250 0 0	
	To Forfeited Shares Account..		250 0 0
	For amount called up on 50 shares in name of John Jones, this day forfeited by resolution of Directors		
„ 31	Forfeited Shares Account .. .. Dr.	100 0 0	
	To Sundry Shareholders' Account		100 0 0
	For amount unpaid on above 50 shares		

To make these processes quite clear an example of the acquisition of a business will be taken. W. Brown, a tailor, after having carried on business successfully for some years, decides to retire and dispose of his business to a limited company. His assets consist of his freehold shop and premises valued at £4,500; stock-in-trade, £500; book debts, £3,000; cash at bank and in hand, £350. His liabilities are, on bills payable £280, and on open accounts £420, leaving as his capital £7,650. The company takes over all the assets except the cash, and undertakes to discharge the liabilities. The excess of the assets acquired over the liabilities assumed is, therefore, £7,300. The price required by Brown is £9,000, the difference being the amount charged by him for goodwill. He agrees to accept payment of this price, £6,000 in cash and £3,000 in shares. The journal entries necessary to record the transfer and payment are as follows:

The order of the liabilities as given in the form is (1) the capital, showing the number of shares and the amount per share paid, with particulars of any arrears and forfeited shares; (2) the debts and liabilities, showing loans on mortgages or debenture bonds, debts on bills, open accounts and for interest and also any amounts due to shareholders for unclaimed dividends; (3) any reserve funds; (4) the balance of the profit and loss account available for dividend; and (5) any contingent liabilities, being either claims not acknowledged as debts or amounts for which the company is only contingently liable.

The order of the assets is: (1) property held by the company, showing (*a*) immovable property, distinguishing freehold and leasehold land and buildings; and (*b*) movable property, distinguishing stock, plant, etc., and giving both cost and deductions for depreciation; (2) debts owing to the company, showing those considered good for which the company (*a*) holds bills or (*b*) has

1	Freehold Premises .. .. Dr.	4,500 0 0	
	Stock .. .. „	500 0 0	
	Sundry Debtors.. .. .. „	3,000 0 0	
	Goodwill .. .. „	1,700 0 0	
	To W. Brown Purchase Account		9,700 0 0
	For the price of assets purchased as per agreement dated		
	W. Brown Purchase Account .. .. Dr.	700 0 0	
	To Bills payable		280 0 0
	Sundry Creditors..		420 0 0
	For liabilities assumed by Company under Agreement dated		
	W. Brown Purchase Acc[illegible] Dr.	3,000 0 0	
	To Share Capital Acco[illegible]		[illegible] 0 0
	For shares allotted t[illegible] payment for business [illegible] per agreement dated		

Brown will also be debited and cash credited with the £6,000 payable in cash as and when the amount is paid. The student should now open the ledger accounts and post thereto the various journal and cash book entries in order that the full effect of the transactions may be appreciated.

Companies' Balance - Sheets. The assets and liabilities of limited companies are not, as a rule, arranged in the same order in the balance sheet as those of an individual or a firm. Table A of the Companies' Act, 1862, besides providing a model set of regulations for a company, also gives a form of balance-sheet to be used by companies governed by those regulations; and the order there laid down is very generally adopted by companies having articles of association of their own.

no security, and those considered doubtful or bad (any debt due by an officer of the company must be separately stated); (3) cash and investments, showing the natures of the investments and the whereabouts of the cash.

Companies' Profits. One point that emerges from the foregoing is that the balance of the profit and loss account is not transferred to the capital account, but is shown separately and distinctly in the balance-sheet. This is always necessary in the case of a company, whatever has been the result of the trading. If there has been a loss the balance will appear on the assets side of the balance-sheet. The disposal of the profit is usually shown in the ledger in an account called the Appropriation of Profit Account, a specimen of which, with the balance-sheet of a company, is given later.

Continued

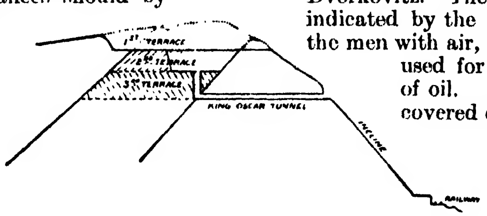
MAKING A MINE

Various Methods of Attacking Hidden Deposits. Shafts and Levels. Petroleum Wells. Pillar and Stall Work. Timbering and Stoping

By D. A. LOUIS

THE transition stage for open-cast to underground working is shown by diagram in 55. The first and second terraces have been worked open-cast, but the tunnel has been driven in at the level of the third terrace to expedite the transference of the ore to the railway.

Bell Pits. The bell pit is perhaps the simplest, and, at all events, the least pretentious of underground workings; it is applicable only to shallow deposits not deeper than 50 ft. or so, with good solid strata or beds above. It is an ancient and primitive method of working, but under some circumstances should by no means be despised. A shaft as small in size as is feasible is sunk, and is widened out at the bottom to as large an extent as is consistent with safety. A *windlass* or a *whip*, or *whipsyderry*, erected at the top of the shaft, suffices for drawing up the rock and mineral in ordinary buckets or the larger mining bucket or *kibble*.



55. TRANSITION FROM OPEN-CAST TO UNDERGROUND WORKING

In the case of the whipsyderry, the rope from a pulley in the head-gear, instead of being wound on and off a windlass, passes under a pulley on the ground, and is hitched to a horse, the load being raised or lowered by walking the horse away from or towards the shaft. When the deposit is worked away as far as safety permits, the pit is abandoned. One or several pits may be at work at the same time, but between adjoining workings a wall of unworked deposit is left to support the roof and to prevent the pit collapsing.

Hand Dug Petroleum Wells. Shallow deposits of petroleum are, in some localities, worked by means of shafts, and men go down these and fill buckets with the oil, which is drawn to the surface by windlass or whim. And odd-looking figures the men look when they come up reeking with oil. Fig. 58 represents a scene witnessed by the writer in Roumania, from a photograph by Dr. Dvorkovitz. The position of the wells is indicated by the bellows used to supply the men with air, and by the horse whim used for drawing up the buckets of oil. Alongside each well is a covered circular tank into which the oil is run from the buckets. Two of these tanks are shown at the centre of the picture, with people standing on the cover.

The Horse Whim. The horse whim consists of a drum or short wooden cylinder, upon which the rope from the shaft winds. This drum has a vertical shaft working in a foot piece on the ground and supported above by a transverse beam raised on standards at each end. A crosspiece extends horizontally from the shaft below the drum and forms two arms, to one of which the horse is attached, the rope making a few turns round the drum. The horse is driven in one direction until one bucket is lowered to the bottom and the other raised to the surface; and then, by reversing this course, the latter bucket, having been emptied at the tank, is made to descend, while the other, which has been filled below, is drawn up.

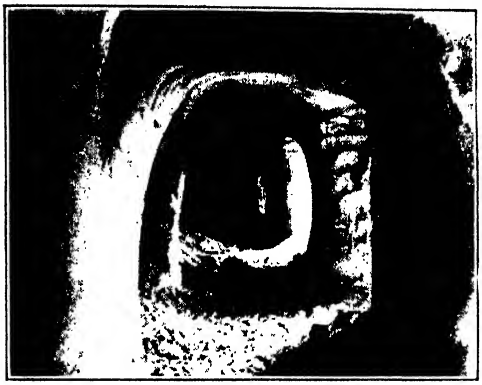
56. DAY LEVEL, FULLERS' EARTH MINE AT MIDFORD, NEAR BATH
Photograph by the Geological Survey

Petroleum Wells. Usually, however, with petroleum a borehole suffices for the extraction of the oil, and, in fact, the oil rises in the borehole in most instances and discharges itself at the surface. This occasionally happens with great violence, and the petroleum is projected many feet in a great jet, sometimes even wrecking the whole derrick and plant. This appearance of petroleum is known as a *spouter* or *fountain*. When oil does not

rise of its own accord in a petroleum well and where conditions are suitable, as they are in Canada, Pennsylvania, and Galicia, for instance, the oil is extracted by means of pumps. When conditions do not permit of the use of pumps, as at Baku, in Russia, where sand accompanies the oil and would interfere with the valves of pumps, bailing is resorted to. That is, long narrow buckets, attached to a rope run down the borehole into the oil, are allowed to fill, and are then wound up again and emptied at the surface, to be let down and refilled, and so on.

Longwall and Pillar-and-stall Working. Such simple methods as these can, however, rarely be adopted advantageously, and to work a deposit by underground methods entails a well-considered and systematic plan of operations which requires adaptation to suit each particular case, and is based on certain general and well-defined principles. For instance, if the deposit be more or less horizontal, it will be approached by a shaft, or two shafts, and will be worked away by driving large passages in the deposit, which may then be removed in long slices or cuts, similar to the long cuts or slices removed in working the iron ore in Lincolnshire already mentioned.

Or the deposit may, perhaps, be better worked by making comparatively short and narrow cuts, leaving blocks unworked to support the roof, such as the system seen in the limestone workings near Dudley, or in the Beer stone quarries, or the Chiselhurst chalk caves. Even sand may be worked in this way; the photograph [57], by Miss Mary Johnston, shows workings of this description in the Lower Greensand beds at Godstone, in Surrey. It is remarkable that, although the bed is quite loose silver sand when disturbed, yet the pillars are quite sufficient to support the workings. The former system is known as *longwall* working; the latter system as *pillar-and-stall* working. These systems are employed mostly for working bedded deposits, but some veins and masses are worked to advantage by these methods.



57. PILLAR AND STALL WORKINGS IN SAND
Photograph by the Geologist's Association

58. HAND DUG OIL WELLS, BUSTENARI, ROUMANIA

59. TIMBER AND STEEL SUPPORTS IN A LEVEL

Vein Mining. When, however, a deposit is steeply inclined, or vertical, a shaft for working may occasionally be sunk in the deposit itself, and side passages or *levels* driven from it at convenient depths apart in the deposit itself, which is then worked by removing from overhead, termed *overhand stoping*, or by digging it away from under foot, termed *underhand stoping*. In this class of mining, it is frequently better to sink the shaft in firm ground to the dip of the vein, so that the latter will be intercepted at some specified depth. Then passages, known as *cross-cuts*, are driven through the country to meet at right angles the veins, which are worked by the passages in or alongside the vein or levels and stopes as in the previous case. Veins generally, and many tilted bedded deposits occasionally, are worked by shafts, levels, and stoping.

Adits and Day Levels. Whenever it is possible to do so, the deposit would be preferably worked by an *adit* or *day level*—that is, a passage driven from the open air either on the deposit itself or as a cross-cut to meet the deposit at right angles. The latter practice is generally preferable, as it ensures the strong level being in country, and also serves to explore any parallel veins. Adit mining, however, can be appropriately adopted only in hilly or mountainous regions where there is a considerable extent of the deposit above the point where the day level would be driven. This is frequently the case, and day-level or tunnel working should be used wherever these suitable conditions obtain. It is more economical than shaft mining, inasmuch as, instead of having to raise the ore from the mine by machinery, with a possible considerable outlay for power, the ore from above reaches the day level by gravity, and has simply to be trammed or otherwise got along the day level to the open air. When the day level serves to drain the mine, it is called an *adit*, and saves the expense of pumping in the area above it. But even in the case of an adit a vertical shaft would be sunk from the surface above to meet it at its inner end, so as to create a current of air for ventilation, and as a supplementary means of access to the mine, which can be useful in various ways.

Driving the Adit. The *adit* would be driven in the same way as the costeaning drifts already described, but of a larger size, as it would probably be the main outlet. It would be carefully timbered where required, and would be given a slight but regular fall towards the mouth, so as to allow water to flow out and to have the grade in favour of the heavier full waggons. Fig. 59, from a photograph by Mr. Williams, illustrates two modes of supporting a gallery all round; immediately in front the supports are of timber, while at the back they take the form of steel rail arches.

The day level may, however, be comparatively insignificant, as, for instance, at the fullers' earth mines near Bath [56], where small work serves the purpose quite well. These workings are very closely timbered; some of the timbers may be seen projecting at the mouth of the adit. On the other hand, where operations are conducted on a more extensive scale the adit is given commensurate dimensions; Fig. 60, for instance, represents an entrance to an iron ore

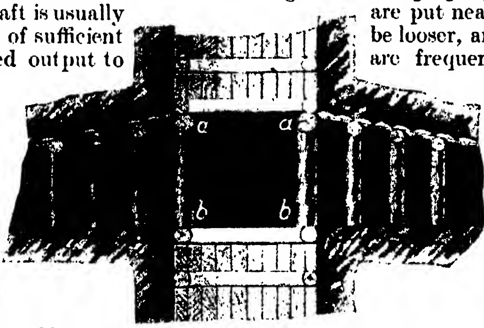
60. DAY LEVEL, GRANGESBERG IRON ORE MINE, SWEDEN

mine in Sweden, where a large and heavy output has to be maintained, and the adit is in consequence quite a dignified tunnel.

It is extremely desirable to have the main artery as secure as possible, whether it be shaft or level.

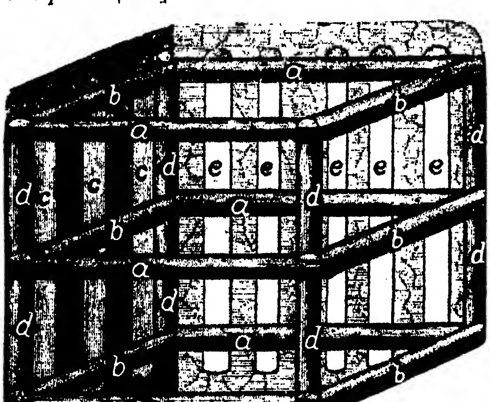
The Shaft. *The position of a shaft for vein mining* would be determined by the preliminary investigations. The site would be selected so that as great a part of the mining as possible could be done with a minimum amount of cross-cutting. Vertical shafts are generally preferred because they are easier to sink, and they are more convenient for winding both men and material, as well as being better adapted for pumping purposes. There is a fascination in following the downward course of a lode by an inclined shaft, inasmuch as it gives some information about the character of the vein all the while the sinking is progressing; but this generally proves a poor recompense for the subsequent inconvenience. Moreover, the ground in the vein is rarely as reliable as the country, which is a very great consideration with such an important piece of work as a shaft.

In metal mining the shaft is usually rectangular, and is made of sufficient size to allow the proposed output to pass, to accommodate pumping rods, and to provide a ladderway; 10 ft. by 7 ft. is an average dimension. When the size and position of the shaft have been decided and the character of the ground does not provide room for depositing waste, or where there is danger from flooding, the mouth of the shaft is raised above the surrounding level. The shaft is sunk in the same way as the costeaning pit, but with more care, especially in the timbering and in ensuring verticality.



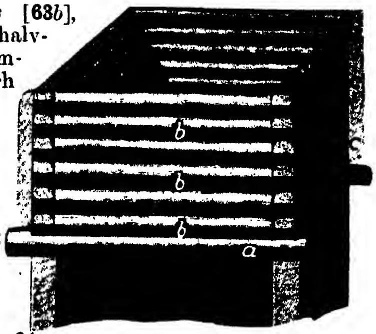
62. INTERSECTION OF SHAFT AND LEVELS

Timbering the Shaft. The timbering usually takes the form of frames of square timber, consisting of two larger pieces called *wall-plates* [63*a*] and two shorter ones called



63. TIMBER SHAFT SUPPORTS

end-pieces [63*b*], joined by halving the timber at each end. The separate frames, when required, are kept apart by the introduction of distance-pieces or



61. CLOSE TIMBERING IN A SHAFT

studdles [63*d*], and where there is danger of loose ground falling in, *lagging* of boards [63, *c*, *e*], called *backing deals*, or of poles or small wood is packed behind the frames. And as occasion demands, corner-pieces are nailed in to keep the frames in position; and lashing deals, nailed inside from frame to frame, are employed when it is desired to bind them all together until properly supported. The frames are put nearer together if the ground be looser, and, at the top of the shaft, are frequently set continuous [61]. When the shaft is divided into compartments, timbers called *buntons*, or dividers, are fixed across the shaft parallel to the end-pieces. Planks or *casing-boards* are nailed to the buntons to form a continuous partition; the buntons also carry the cage guides and assist in supporting the ladder platforms. The timbering is supported in the shaft by special brackets or *bearers*. In some cases the end-pieces are made long enough to project beyond the wall-plates and rest in niches in the rock.

Plats are excavated in the side of the shaft to provide retiring places for men during blasting operations while sinking is in progress. They serve, subsequently, as places for ore bins when working with a skip.

Levels or Cross-cuts. To connect the shaft with the deposit to be worked, galleries are driven out from it at distances varying from 50 ft. to 100 ft, apart. Fig. 62 shows galleries branching from each side of a shaft and a mode of timbering. If these are driven in the country they are called *cross-cuts*, and if in the vein, *levels*; they are secured by timbering as circumstances demand, are slightly graded, the fall being towards the shaft, while a gutter is provided to carry away any water; 6 ft. to 7 ft. by 4½ ft. wide is an ordinary size for a level; 7 ft. high by 6 ft., 7 ft., or more wide is a large size, but it is well to have plenty of room, to facilitate tramming and ventilation. Photograph 64 was taken in Foxdale lead mine, in the Isle of Man. It shows lead miners at work,

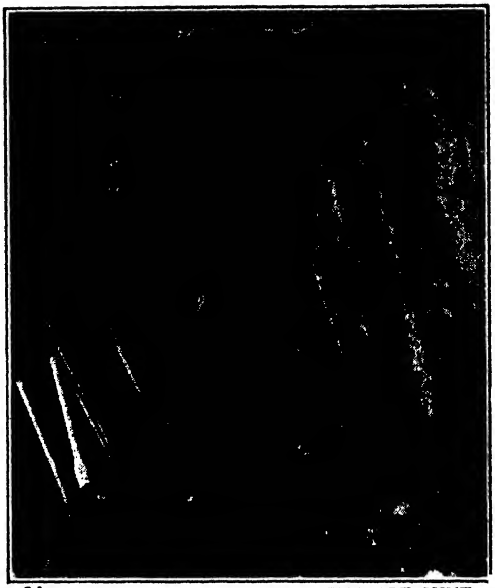
and one side of the drift is firm rock and requires no support. Notice also the picks, drills, hammer, shovel, wheelbarrow. Fig. 65 shows a mode of supporting levels used in the Transvaal.

Winzes. Small connecting shafts are *sunk* or driven upwards, or *raised* from one level to another, for the purpose of ventilation and also to facilitate the handling of the ore and to break the vein into convenient blocks for working. When driven upwards the work is called a *raise* or *rise*, when sunk, a *winze*; but the completed work is usually called a winze, however made.

Development. Shaft sinking, cross-cutting, level driving, making raises or winzes, excavating adits—all these operations are known as *dead-work*, or development work. And except when any of this work is done on the vein, development work does not yield ore, but thorough development is one of the most important factors in good mining practice. For not alone should a good lot of ground be opened up or *laid open* ready for the removal of ore or *productive work* before these latter operations are started, but even when the mine is in full swing development work should be kept well ahead of the productive work. A good example of development work being done at a profit, which, however, very rarely happens, came within the writer's experience when a shaft was sunk 600 ft. in a lead vein to connect with an adit; the ore excavated in making the shaft more than paid for the whole work.

Productive Work in Vein Mining. This should be started only when the development work is well advanced, when plenty of ore has been blocked out by levels and winzes, and when there are plenty of *backs*—that is, ore above the levels; then, and then only, should the actual winning of the ore or *stoping* be started. This is done either by digging out the ore below the level—that is, by *underhand stoping*—or by taking it out from overhead—that, is by *overhand stoping*.

Underhand Stoping. Underhand stoping is commenced by digging a hole in the floor of the level to the depth of a few feet and tramming the material away, when the excavation is about three times as long as it is deep; it is deepened by sinking another hole at the centre and following on by attacking the material on each side of this hole. The excavation at the top is then enlarged by cutting away a block of ground at each end. The hole at the centre is next deepened another stage, and so the work goes on, removing blocks from the top and each succeeding stage in descending order, always deepening the centre hole in its turn. The excavation very soon looks like two rough kinds of staircases, meeting at the bottom, each stage or step being a few feet deep. The excavation is done by pick and shovel, wedge, or gad, and hammer, or drilling and blasting, just as the character of the ground demands; and to deal with the material excavated timber platforms called *stulls* are erected, and upon these the worthless stuff, *attle*, is thrown, while a [illegible] lass and buckets serve for drawing up the ore to the level, to be trammed to the shaft and wound to surface. When the excavation reaches the level below, hoppers or *shoots* are put in, and into these the ore is charged, and the trouble and expense of winding to the level above is saved. For this reason, too, an underhand stope can be advantageously woiked at the side of a winze, for then the ore is allowed to fall down the winze to the level below.



64. LEAD MINERS AT WORK. FOXDALE MINE, ISLE OF MAN

65. STONE WALL AND TIMBER SUPPORTS IN THE TRANSVAAL

Continued

ADMIRALTY & WAR OFFICE POSTS

Clerical, Engineering, and Surveying Posts in the Army and Navy Departments. The Coastguard Service

By ERNEST A. CARR

Appointments for Junior Clerks. The vacancies on the junior staff of the Admiralty Supply and Accounting Departments, the Royal Ordnance Factories, and the Army Accounts branch of the War Office, are filled by means of joint open competitions, to which all candidates between the ages of 18 and 20 are admissible. Examinerships in the Exchequer and Audit Office are also offered at the same contests, but for the present we are interested only in the Admiralty and War Office appointments. It should be noted that the age limits are extended in favour of persons who have served in the Army, Navy, Royal Irish Constabulary, or Civil Service. Competitors are allowed to enter for any post for which they are eligible, and, if successful, to choose among existing vacancies in the various offices named, according to their position on the combined pass list. The examination fee has very recently been reduced from £6 to £3.

So far, at least, as the two "fighting departments" are concerned, these situations should be distinctly attractive to any well-educated youth whose ambitions extend beyond the Second Division or Excise but who cannot afford the special training needed in order to win a first-grade position. They offer both a very fair salary and excellent prospects of promotion. Except in the Ordnance Factories, the holders of junior appointments escape the monotony of ordinary office life by changes of station and a considerable spell of foreign service. Few clerks, indeed, on the home Civil Service staff are as fortunate in this respect.

These officers are all appointed at a uniform scale of pay. For the first two years they are on probation at a fixed salary of £100. It is then raised to £120, and progresses by £10 yearly to £200, and afterwards by £15 to a maximum of £350. But that figure does not by any means represent the average value of such appointments, for there are many higher staff positions attainable, with salaries ranging up to £800 or more, and valuable allowances in addition.

The Naval Service. Under the Admiralty, most of these higher positions are at the dockyards and naval stations at home and abroad. All officers serving abroad are granted local allowances, and either a house or a further allowance instead. It is the practice of the authorities to limit the term of foreign service to about 12 years, of which some five years may be spent at tropical stations, and the remainder in temperate climates. As officers are rarely kept at one station more than three years in the tropics or five years elsewhere, their service abroad is pleasantly varied.

The possibilities of the Admiralty service are best illustrated by official figures. In a total staff of 187, exactly 100 posts carry a maximum salary of at least £500 a year, and of this number 26 are remunerated with £700 or upwards, irrespective of allowances.

War Office Posts. Successful candidates who elect to enter the Army Accounts Department are appointed on the express understanding that they are liable to serve either at the War Office or at any station at home or abroad where our troops may be serving. Changes of station are, in fact, frequent, but foreign service seldom extends beyond a few years—seven at most—and is rewarded with extra allowances to cover the increased cost of living abroad. Officers are appointed in the first instance as Assistant Accountants of the second class, but those who show aptitude for their duties are eligible for promotion to the first class and to higher positions. As a further encouragement to men of ability, there is a provision that officials of at least five years' service in the department may have their salary specially raised to £215 a year. The staff of the Army Accounts branch is constituted as follows:

228	£100 to £350
140	£350 — £15 — £500
55	£550 — £20 — £700
2	£850
14	£850 — £50 — £1,000
439	

Appointments in the Royal Ordnance Factories are far fewer in number, and do not involve foreign service, officers being attached to Woolwich, Waltham Abbey, Enfield Lock, or Birmingham, as the needs of the service require. They have assured prospects of at least £500 a year, with chances of £700 or more; but this branch of the service does not afford as much scope as the accountancy section already discussed. A competitor who succeeds in taking a high place on the combined list would therefore be well advised (if he has no objection to foreign service) to select the Admiralty as a career, and in default the Army Accounts, in preference to the Ordnance Factories.

The Competitions. Candidates are at liberty to take up all the first five in the following list of subjects, and any two of the remainder. Of course, no one would have the smallest chance of success who offered less than the maximum number permitted. Failure in arithmetic or composition disqualifies for an appointment. A detailed syllabus, setting out the precise scope

and character of the examination in each subject, may be obtained from the Civil Service Commission.

1. Mathematics I. — Arithmetic, geometry (Euclid I. to VI., or work equivalent in scope), algebra, simple trigonometry, dynamics, and statics, with graphs and practical work.

2. Latin, with either Latin verse or Roman literature.

3. French or German, including conversation and writing a letter or essay in the language.

4. English composition and précis writing, and the reproduction of a passage read out.

5. Geography.

6. Mathematics II.—Solid and co-ordinate geometry, the calculus, etc., with a practical paper.

7. The modern language not taken under heading 3.

8. Greek.

9. History.—English, and a special period in European history.

10. Experimental science (physics and chemistry), with simple practical work in each section.

In the last subject, 75 per cent. of the total marks may be gained by a thorough knowledge of *either* branch.

Engineering and Surveying Posts. Candidates for the somewhat valuable position of assistant civil engineer in the Admiralty must be between 23 and 28 years of age, and must satisfy the authorities that they are qualified in respect of technical education and practical training. On the latter point the standard prescribed is at least three years' satisfactory service with a civil engineer or architect in good general practice, or a leading engineer in the dockyards or the Army. Except in English composition, the examination scheme is wholly technical. It includes mathematics and applied mechanics, surveying, hydraulic and sanitary engineering, drawing-office work, specifications, quantities, and estimates. On appointment, these officers receive £200 a year, rising to £300. When made Admiralty civil engineers, they start at the latter figure and advance to at least £550, with a house allowance, and with further prospects up to £1,200. The civil staff of the War Office includes a few professional posts corresponding generally with the Admiralty appointments.

The nomination of the First Lord, coupled with an examination similar to that prescribed for engineering posts, but less searching in its scope, admits trained men between the ages of 21 and 30 to the grade of assistant surveyor to the Admiralty. They begin at £150 a year, with a maximum of £400 as assistants and £600 as surveyors; and for them, as for their engineer colleagues, there are considerably higher positions within reach. For the special regulations framed for each of these classes of appointment application should be made to the department concerned.

Assistant Clerks in the Navy. Youths who covet a sea life but have not been able to undergo the long, expensive training exacted of budding naval officers, should turn their attention to the limited competitions for assistant clerkships in the Navy, admitting to the well-paid and attractive calling of naval paymaster. Probably because the advantages of this service are not as well known as they deserve to be, the competition for vacancies is not very severe; and the entrance examination offers no serious obstacle to a well-educated lad with a fair knowledge either of three foreign languages or of two languages and the elements of natural science.

Many would-be competitors are discouraged from entering by the fact that a nomination is requisite for these appointments. But this difficulty is more apparent than real, as private influence with the naval authorities is not imperative to secure the right to compete. A nomination by the First Lord of the Admiralty is readily granted to suitable candidates. Application should be made to his private secretary as soon as the lad for whom it is sought reaches the age of 16. The contests, which have hitherto taken place half-yearly, will in future be held each June—probably for about 40 vacancies—and candidates must be between 17 and 18 years old on the 15th of the following July. They must also be well developed and active for their age, and physically suited in all respects for service in the Navy. Short sight will not necessarily disqualify those who are otherwise fit.

The character of the entrance examination is shown by our schedule of subjects and marks, which relates to a competition for 19 places lately attended by 47 aspirants.

EXAMINATION FOR ASSISTANT CLERKS IN THE NAVY

Order of Merit.	Obligatory.						Optional: Any two may be taken.				Total.
					Alternative.						
	Arithmetic.	Mathematics.	English (Handwriting, Composition, etc.).	Geography and English History.	French.	German.	Latin.	Greek.	Elementary Science.	German or French.	
Maximum	500	600	700	400	600	600	600	600	600	600	4,000
No. 1 ..	330	312	475	257	450	--	495	572	—	—	2,891
No. 19 ..	310	306	325	123	430	—	224	—	365	—	2,143

A note may be added on these subjects. Mathematics consists of algebra, geometry, and trigonometry; the test in English includes précis and shorthand (the latter being of special importance); and the English history paper has particular reference to the period since 1485. In modern languages special attention is given to the oral examination, and the language

not offered as obligatory may be taken as an optional subject. The science papers relate to mechanics, heat, physics, and inorganic chemistry, and include practical tests.

Successful candidates are appointed as assistant clerks at 2s. 6d. a day, and while in that grade must be furnished by their parents or guardians with an allowance of £20 a year. After a year's service, and on passing a further examination, they are rated as clerks at 4s. a day. Their further prospects may be judged from official statistics of the Service.

No.	Grade.	Pay. Per Day.	Pay. Per Annum.	
	Assistant Clerks	2/6	£45 12	
	Clerks	4/-	£73 0 "	
	Assistant Paymasters	5/- to 11/6	£91 5 0 to £200 17 6	vith ten llowanc
	Paymasters (in three classes) ..	14/- to 33/-	£255 10 to £602 5	
12	Paymasters-in-Chief		£693 10 0	s pol

These figures show that speedy promotion is assured, at least to the grade of junior paymaster, for an officer whose conduct and abilities are satisfactory. And the rates of pay are high enough to render him self-supporting after the first year of his sea service—a great advantage to candidates whose relatives are not wealthy.

It need only be added that the sea life is a pleasant and varied one, and that the paymaster's post is generally regarded as the easiest berth in the ship.

Writers and Others. The clerical staff of the Admiralty includes a number of subordinate officers known as writers, and employed both afloat and ashore. Their ranks are recruited in part from applicants trained for the Service at Greenwich Schools, partly by competitive examinations in simple English subjects, shorthand, and typewriting, held half-yearly at the chief naval posts.

Candidates must be between 18 and 23 years of age, and at least 5 ft. 5 in. in height and 32 in. round the chest. In the Fleet they receive 2s. a day on appointment, rising to 6s., with free rations. The dockyard rates begin at 4s. a day, and candidates who display aptitude for the work may obtain higher-grade posts, in which their pay may rise to a maximum of 11s. daily.

Executive posts in the fleets and naval bases—such as are obtained, for example, by means of the examinations for boy artificers and dockyard apprentices—are considered part of the Navy proper, and will therefore be discussed in the section on that subject which is to succeed the present course. For our purpose, the Civil side of the Admiralty may be completed by a few words on the conditions of entry and rates of pay which obtain in the Coastguard Service.

Coastguard Service. Seamen of good character who have completed nine years' continuous service, and are recommended by their captains, are eligible for admission to the Coastguard under the following conditions. They must be trained men or holders of a torpedo or gunnery rating, not over 37 years of age, able to swim and to read and write, and willing to re-engage, if necessary, for continuous service to complete their time for a pension. A limited number of stokers of eight years' service are also admitted, and carpenters who have served for ten years in the Fleet with "very good" character may be appointed as divisional carpenters in the Coastguard.

Coastguard men are liable to be embarked in turn for such cruises as the Admiralty may appoint, and if found unfit for active service at sea may be discharged with a pension or gratuity, according to the length of their service. Otherwise they are retained until the age of 50, or, in the case of chief boatmen-in-charge, until 55, when they retire on a life pension.

Apart from the commissioned officers, who number only 103, the strength, ratings, pay, and allowances of the Coastguard Service are as stated in the table on this page. Modest as are the rates of pay in themselves, it must be remembered that the provision of free quarters is a valuable one, and that with this advantage and a liberal allowance for rations, the coastguard's needs are small.

RATES OF PAY AND ALLOWANCES FOR COASTGUARD SERVICE

No.	Rating.	Provision Allowance. £ s. d.	Other Emoluments.
247	Divisional Chief Officers	182 10 0	Allowance for Quarters.
	Chief Officers	109 10 0	
	" rising in 10 years to .	146 0 0	
4019	Chief Boatmen-in-charge	57 15 10	
	Chief Boatmen	39 10 10	Free Quarters.
	" after 4 years	44 2 1	
	Commissioned Boatmen	31 18 9	
	Boatmen	28 17 11	
	Divisional Carpenters ..	50 3 9	£4 11s. 3d. Tool Money.

Good Conduct Badges, 1d. a day for each badge. All except Divisional Carpenters, 1d. a day when qualified as Trained Men.

Continued

FRACTIONS & QUADRATIC EQUATIONS

Division of Fractions. Reduction of Compound Fractions. Equations with Fractions. Definition of and Methods of Solving Quadratic Equations

By HERBERT J. ALLPORT, M.A.

FRACTIONS—continued

87. Division of Fractions. Let $\frac{a}{b}$ and $\frac{c}{d}$ be two fractions, and let x denote the quotient $\frac{a}{b} \div \frac{c}{d}$. Then

$$x \times \frac{c}{d} = \frac{a}{b} \div \frac{c}{d} \times \frac{c}{d}.$$

But, if we divide $\frac{a}{b}$ by any quantity and then multiply the quotient by the same quantity, it is clear that the result is $\frac{a}{b}$. Thus

$$x \times \frac{c}{d} = \frac{a}{b}.$$

Therefore, $\quad x \times \frac{c}{d} \times \frac{d}{c} = \frac{a}{b} \times \frac{d}{c}.$

But $\quad x \times \frac{c}{d} \times \frac{d}{c} = \frac{xcd}{cd} = x.$ [Art. 86.]

Hence, $\quad x = \frac{a}{b} \times \frac{d}{c}.$

That is, *to divide one fraction by another, invert the divisor, and proceed as in multiplication.*

88. Both in multiplication and division we must, of course, reduce the result to its lowest terms by cancelling common factors of the numerator and denominator.

Example **1.** Simplify

$$\frac{x^2+xy}{x^3-x^2y} \times \frac{x^4-x^3y}{x+y}.$$

We resolve the numerators and denominators into factors, and cancel those which are common to the numerator and denominator of the product. Thus

$$\frac{x^2+xy}{x^3-x^2y} \times \frac{x^4-x^3y}{x+y}$$
$$= \frac{x\,(x+y)}{x^2\,(x-y)} \times \frac{x^3\,(x-y)}{(x+y)}$$
$$= \underline{x^2 \text{ Ans.}}$$

Example **2.** Simplify

$$\left(\frac{x-2}{2x-3} - \frac{4x-5}{5x-6}\right) \div \left(\frac{2x-3}{3x-4} - \frac{3x-4}{4x-5}\right).$$

The given expression

$$= \frac{(x-2)(5x-6)-(4x-5)(2x-3)}{(2x-3)(5x-6)} \div \frac{(2x-3)(4x-5)-(3x-4)^2}{(3x-4)(4x-5)}$$
$$= \frac{5x^2-16x+12-8x^2+22x-15}{(2x-3)(5x-6)} \div \frac{8x^2-22x+15-9x^2+24x-16}{(3x-4)(4x-5)}$$
$$= \frac{-3x^2+6x-3}{(2x-3)(5x-6)} \div \frac{-x^2+2x-1}{(3x-4)(4x-5)}$$
$$= \frac{-3(x-1)^2}{(2x-3)(5x-6)} \times \frac{(3x-4)(4x-5)}{-(x-1)^2}$$
$$= \frac{3(3x-4)(4x-5)}{(2x-3)(5x-6)} \ \underline{\text{Ans.}}$$

EXAMPLES 25

Simplify the following

1. $\frac{x^3-y^3}{x^3+y^3} \times \frac{x^2-y^2}{(x-y)^2}.$
2. $\frac{x^2+4x}{x+3} \div \frac{x+4}{x^2+3x}.$
3. $\frac{(x-y)^2-z^2}{(x-z)^2-y^2} \times \frac{y^2-(z-x)^2}{z^2-(x-y)^2}.$
4. $\frac{(x^2-y^2)^2}{(x-y)^3} \times \frac{(x+y)^2}{x^4-y^4} \div \frac{(x+y)^3}{x^2+y^2}.$
5. $\left(\frac{x}{x+a} + \frac{a}{x-a}\right) \div \frac{x^2+a^2}{x^2+ax}.$
6. $\left\{\frac{x^2-xy}{x^2+y^2} \div \left(\frac{x}{x+y} - \frac{y}{x+y}\right)\right\} \left\{\frac{x^2-y^2}{x^2+xy} \div \left(1 - \frac{x^2-y^2}{x^2+y^2}\right)\right\}.$
7. $\left\{\frac{1}{x-1} - \frac{9}{x-2} + \frac{10}{x-3}\right\} \times \left\{\frac{1}{x-1} + \frac{2}{x+1} + \frac{5}{1-2x}\right\}.$

89. Compound Fractions. A fraction, whose numerator or denominator is a fraction, is called a compound fraction. The rules already explained enable us to reduce compound fractions to simple fractions.

Example **1.** Simplify

$$\frac{\frac{a+b}{a-b} - \frac{a-b}{a+b}}{\frac{1}{a-b} + \frac{1}{a+b}}.$$

Here we notice that the L.C.M. of the denominators of the fractions which form the numerator of the given expression is a^2-b^2, and that the L.C.M. of the denominators of the fractions which form the denominator of the given expression is also a^2-b^2. Hence, we shall at once have reduced the given expression to a simple fraction if we multiply both numerator and denominator by a^2-b^2. We have $\frac{a+b}{a-b} \times a^2-b^2$ equal to $(a+b)^2$ [Art. 83], and so on for each fraction.

Therefore, the given expression

$$= \frac{(a+b)^2-(a-b)^2}{(a+b)+(a-b)}$$
$$= \frac{(a+b+a-b)(a+b-a+b)}{a+b+a-b}$$
$$= \frac{2a \cdot 2b}{2a} = \underline{2b \text{ Ans.}}$$

Example **2.** Simplify

$$= \frac{1}{a - \frac{1}{a+\frac{1}{a}}} - \frac{1}{a + \frac{1}{a-\frac{1}{a}}}$$

Fractions of this form are called *continued fractions*. They are simplified as in Arithmetic [Art. **88**, page 706] by beginning with the lowest line.

The given expression

$$= \frac{1}{a - \cfrac{1}{\cfrac{a^2+1}{a}}} - \frac{1}{a + \cfrac{1}{\cfrac{a^2-1}{a}}}$$

$$= \frac{1}{a - \cfrac{a}{a^2+1}} - \frac{1}{a + \cfrac{a}{a^2-1}}$$

$$= \frac{a^2+1}{a(a^2+1)-a} - \frac{a^2-1}{a(a^2-1)+a}$$

$$= \frac{a^2+1}{a^3} - \frac{a^2-1}{a^3}$$

$$= \frac{a^2+1-a^2+1}{a^3} = \frac{2}{a^3} \quad \underline{\textit{Ans.}}$$

90. Proper and Improper Fractions. A proper fraction is one whose numerator is of lower degree than its denominator.

A fraction whose numerator is not of lower degree than its denominator is called an improper fraction. Thus

$$\frac{2x-3}{x^2+5x-9}$$

is a proper fraction ; while

$$\frac{2x-3}{4x-1} \text{ and } \frac{2x^2-5x+1}{5x-4}$$

are improper fractions.

An improper fraction can be expressed as the sum of one or more integral terms and a proper fraction, by division. Thus,

$$\frac{2x-3}{4x-1} = \frac{\frac{1}{2}(4x-1)-\frac{5}{2}}{4x-1}$$

$$= \frac{1}{2} - \frac{5}{2(4x-1)}.$$

EQUATIONS WITH FRACTIONS

91. An equation containing fractions may be reduced to an equation without fractions by multiplying each side of the equation by the L.C.M. of the denominators of all the fractions which occur.

Example **1.** Solve

$$\frac{x-1}{x+3} - \frac{x+2}{x-4} + \frac{10}{x} = 0.$$

The L.C.M. of the denominators is $x(x+3)(x-4)$, and, multiplying each side by this expression, we get

$x(x-4)(x-1) - x(x+3)(x+2) + 10(x+3)(x-4) = 0.$

Therefore,

$x^3 - 5x^2 + 4x - x^3 - 5x^2 - 6x + 10x^2 - 10x - 120 = 0$

Therefore,

$$12x = -120$$

$$x = -\ \underline{10\ \textit{Ans.}}$$

The work is shorter if we reduce improper fractions to proper fractions.

Example **2.** Solve

$$\frac{16x-13}{4x-3} + \frac{40x-43}{8x-9} = \frac{32x-30}{8x-7} + \frac{20x-24}{4x-5}.$$

Dividing each fraction by its denominator we get

$$4 - \frac{1}{4x-3} + 5 + \frac{2}{8x-9} = 4 - \frac{2}{8x-7} + 5 + \frac{1}{4x-5}.$$

Therefore,

$$\frac{2}{8x-9} - \frac{1}{4x-3} = \frac{1}{4x-5} - \frac{2}{8x-7}.$$

Therefore,

$$\frac{2(4x-3)-(8x-9)}{(8x-9)(4x-3)} = \frac{(8x-7)-2(4x-5)}{(4x-5)(8x-7)};$$

or

$$\frac{3}{(8x-9)(4x-3)} = \frac{3}{(4x-5)(8x-7)}.$$

Hence,

$$(8x-9)(4x-3) = (4x-5)(8x-7).$$

Therefore,

$$32x^2 - 60x + 27 = 32x^2 - 68x + 35$$

$$8x = 8$$

$$x = \underline{1\ \textit{Ans.}}$$

EXAMPLES 26

Solve the equations

1. $\dfrac{x-6}{4(x-2)} = \dfrac{x-10}{6(x-2)} + \dfrac{1}{9}.$
2. $\dfrac{x}{5(x-2)} - \dfrac{x-2}{5x} = \dfrac{1}{3x} - \dfrac{1}{3x(x-2)}.$
3. $\dfrac{7x+1}{x-1} = \dfrac{35(x+4)}{9(x+2)} + \dfrac{28}{9}.$
4. $\dfrac{2x-1}{2x+3} - \dfrac{x}{3x-2} = 1 - \dfrac{2x(x+3)}{(3x-2)(2x+3)}.$
5. $x - a - \dfrac{ab}{x-b} = \dfrac{x^2+ab}{x-b}.$
6. $\dfrac{11}{12x+11} + \dfrac{5}{6x+5} = \dfrac{7}{4x+7}.$
7. $\dfrac{4(7x-2\frac{2}{3})}{x+4} - \dfrac{3x-26}{\frac{x}{3}+\frac{1}{2}} = \dfrac{13(x+5)}{x+\frac{3}{2}} + 6.$

Simplify the following expressions

8. $\dfrac{x-a}{\frac{1}{a}-\frac{1}{b}} \times \dfrac{a-b}{1-\frac{a}{x}}.$
9. $\dfrac{\frac{1}{a}}{\frac{1}{a}-\frac{1}{b}} \div \dfrac{(a+b)^2-4ab}{\frac{1}{a^2}+\frac{1}{b^2}-\frac{2}{ab}}.$
10. $\dfrac{1+\frac{a}{b}}{\frac{b}{a}-1} \div \dfrac{a^2-b^2}{1-\frac{2b}{a}+\frac{b^2}{a^2}}.$

QUADRATIC EQUATIONS

92. A quadratic equation is an equation which contains the square, but no higher power, of the unknown quantity.

Thus, $2x^2 = 18$, and $5x^2 - x = 6$, are quadratic equations. The first example, which contains *only* the second power of x, is a *pure* quadratic.

To solve a pure quadratic we write the terms which contain x on one side of the equation, and the remaining terms on the other side. Then, by taking the square root of both sides, we obtain two *simple* equations. Thus, if $2x^2 = 18$, we have $x^2 = 9$, and, taking the square root of both sides, $x = +3$, or $x = -3$.

[$x = 3$, or $x = -3$, is always contracted into $x = \pm 3$.]

93. In taking the square root of both sides of the equation $x^2 = 9$, it may seem that we should put the double sign to *both* sides of the result, *i.e.*, $\pm x = \pm 3$. But this would only give the four following cases, $+x = +3$, $+x = -3$, $-x = +3$, and $-x = -3$, and it is easily seen that these four cases give no more values of x than are included in the form $x = \pm 3$. Hence, in taking the square root of the two sides it is only necessary to put the double sign before *one* result.

94. In Article **32**, page 2150, we found that $(x+a)^2 = x^2 + 2ax + a^2$. Now, in the expression $x^2 + 2ax + a^2$, the coefficient of x is $2a$, and, if we take the half of this and square it, we obtain a^2, *i.e.*, we obtain the *third* term of the expression, $x^2 + 2ax + a^2$. Hence, *to complete the square of which $x^2 + 2ax$ are the first two terms we must add the square of half the coefficient of x.*

Example. To make $x^2 + 6x$ into a perfect square we must add $(\frac{6}{2})^2$, *i.e.*, 3^2, or 9. We then get $x^2 + 6x + 9$, which is the square of $x + 3$.

It must be particularly noted that *the coefficient of x^2 is unity.* We cannot, for instance, make $3x^2 + 6x$ into a perfect square by adding the square of half the coefficient of x.

95. The above result enables us to solve a quadratic which contains both the square and the first power of x. For, after putting the terms involving x^2 and x to one side of the equation, and the remaining terms to the other, we can make the first side a perfect square. On taking the square root of both sides, we obtain two simple equations, just as in the case of a pure quadratic.

Example **1**. Solve $x^2 + 4x - 32 = 0$.

Transposing the term -32, we have

$$x^2 + 4x = 32.$$

Since the coefficient of x^2 is 1, the left-hand side of the equation becomes a perfect square if we add the square of half the coefficient of x. The square of half 4 is 2^2. We therefore add this amount to *both* sides of the equation, and obtain

$$x^2 + 4x + 2^2 = 32 + 4;$$

or,

$$(x+2)^2 = 36.$$

Taking the square root we have

$$x + 2 = \pm 6.$$

Therefore,

$$x = +6 - 2 \text{ or } -6 - 2$$
$$= 4 \text{ or } -8.$$

Example 2. Solve $x - 5x^2 = -6$.

Here, the coefficient of x^2 is -5. We must, therefore, first divide every term by -5 in order to make x^2 have unity for its coefficient. Thus

$$x^2 - \frac{1}{5}x = +\frac{6}{5}.$$

We now proceed as in Example **1**. The half of $-\frac{1}{5}$ is $-\frac{1}{10}$, and its square is $(\frac{1}{10})^2$. Therefore,

$$x^2 - \frac{1}{5}x + \frac{1}{10^2} = \frac{6}{5} + \frac{1}{100}$$
$$= \frac{120+1}{100}$$
$$= \frac{121}{100}.$$

Taking the square root,

$$x - \frac{1}{10} = \pm\frac{11}{10}.$$

Therefore,

$$x = \pm\frac{11}{10} + \frac{1}{10}$$
$$= \frac{12}{10} \text{ or } \frac{-10}{10}$$
$$= \frac{6}{5} \text{ or } -1.$$

96. Instead of working every example from the beginning we may use a general formula.

It is clear that, after simplification, a quadratic may contain three terms, *viz.*, a term involving the second power of x, a term involving the first power, and a term without x. Thus, if a, b, and c are supposed to represent *known* quantities, we may take

$$ax^2 + bx + c = 0$$

as a general quadratic equation.

Solving this, by the method of the last article, we must first divide every term by a. Thus,

$$x^2 + \frac{b}{a} \cdot x + \frac{c}{a} = 0;$$

or,

$$x^2 + \frac{b}{a}x = -\frac{c}{a}.$$

Next, add the square of half $\frac{b}{a}$ to both sides, *i.e.*, add $\left(\frac{b}{2a}\right)^2$.

Therefore,

$$x^2 + \frac{b}{a}x + \left(\frac{b}{2a}\right)^2 = -\frac{c}{a} + \frac{b^2}{4a^2}$$
$$= \frac{b^2 - 4ac}{4a^2}.$$

Taking the square root of both sides, we get

$$x + \frac{b}{2a} = \pm\sqrt{\frac{b^2 - 4ac}{4a^2}}$$
$$= \frac{\pm\sqrt{b^2 - 4ac}}{2a}.$$

Therefore,

$$x = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$$
$$= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

This result should be committed to memory, since, by its use, the solution of a quadratic equation can at once be written down.

For instance, in Example 2 of the last article,

$$x - 5x^2 = -6\ ;$$

or

$$-5x^2 + x + 6 = 0$$

we have

$$a = -5,\ b = 1, \text{ and } c = 6.$$

Hence,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-1 \pm \sqrt{1+120}}{-10}$$

$$= \frac{-1 \pm 11}{-10} = \frac{10}{-10} \text{ or } \frac{-12}{-10}$$

$$= -1 \text{ or } \frac{6}{5}.$$

97. Solution by Factors. The product ab is evidently zero if either a or b is zero. Hence, if we know that ab is zero, we know that either $a = 0$, or $b = 0$.

Similarly, if $(x - 1)(x + 2) = 0$, we know that either $x - 1 = 0$ or $x + 2 = 0$, and therefore $x = 1$ or $x = -2$. Thus, the solution of the equation $(x-1)(x+2) = 0$ is $x = 1$ or -2.

In the same way the solution of the equation $(x+2)(x+3)(x+4) = 0$ is $x = -2$ or -3, or -4.

Hence, *to solve any equation involving only one unknown quantity, transpose all the terms to one side of the equation, resolve the expression into factors, and put each factor separately equal to zero. The values obtained from these equations will be the roots of the given equation.*

Example. Solve $x - 5x^2 = -6$.

Transposing

$$5x^2 - x - 6 = 0.$$

Therefore,

$$(5x - 6)(x + 1) = 0.$$

Therefore,

$$5x - 6 = 0,$$

which gives

$$x = \frac{6}{5}\ ;$$

or

$$x + 1 = 0,$$

which gives

$$x = -1.$$

EXAMPLES 27

Solve, without substituting in the formula of Article 96,

1. $x^2 - 7x = 10$.
2. $2x^2 + x - 3 = 0$.
3. $(x + 4)^2 = 16x + 1$.
4. $x^2 - 15 = 5 - 8x$.
5. $9(2x+1)^2 = (x-2)^2$.
6. $x^2 + 6a^2 = 5ax$.

Solve, by the formula of Article 96,

7. $6x^2 = 13x - 6$.
8. $(x + 3)^2 = 9(x - 1)^2$.
9. $132x^2 - 13x = 2$.
10. $2x^2 + x - 6 = 0$.
11. $8x^2 + 17 = 70x$.
12. $20 = 3x + 2x^2$.

Solve, by resolving into factors,

13. $x^2 - 2ax + a^2 - b^2 = 0$.
14. $x^3 - 5x^2 - 8x + 12 = 0$.
15. $x^4 - 13x^2 + 36 = 0$.
16. $2x^3 - 4 = 8x + x^2$.

Answers to Algebra

Examples 23

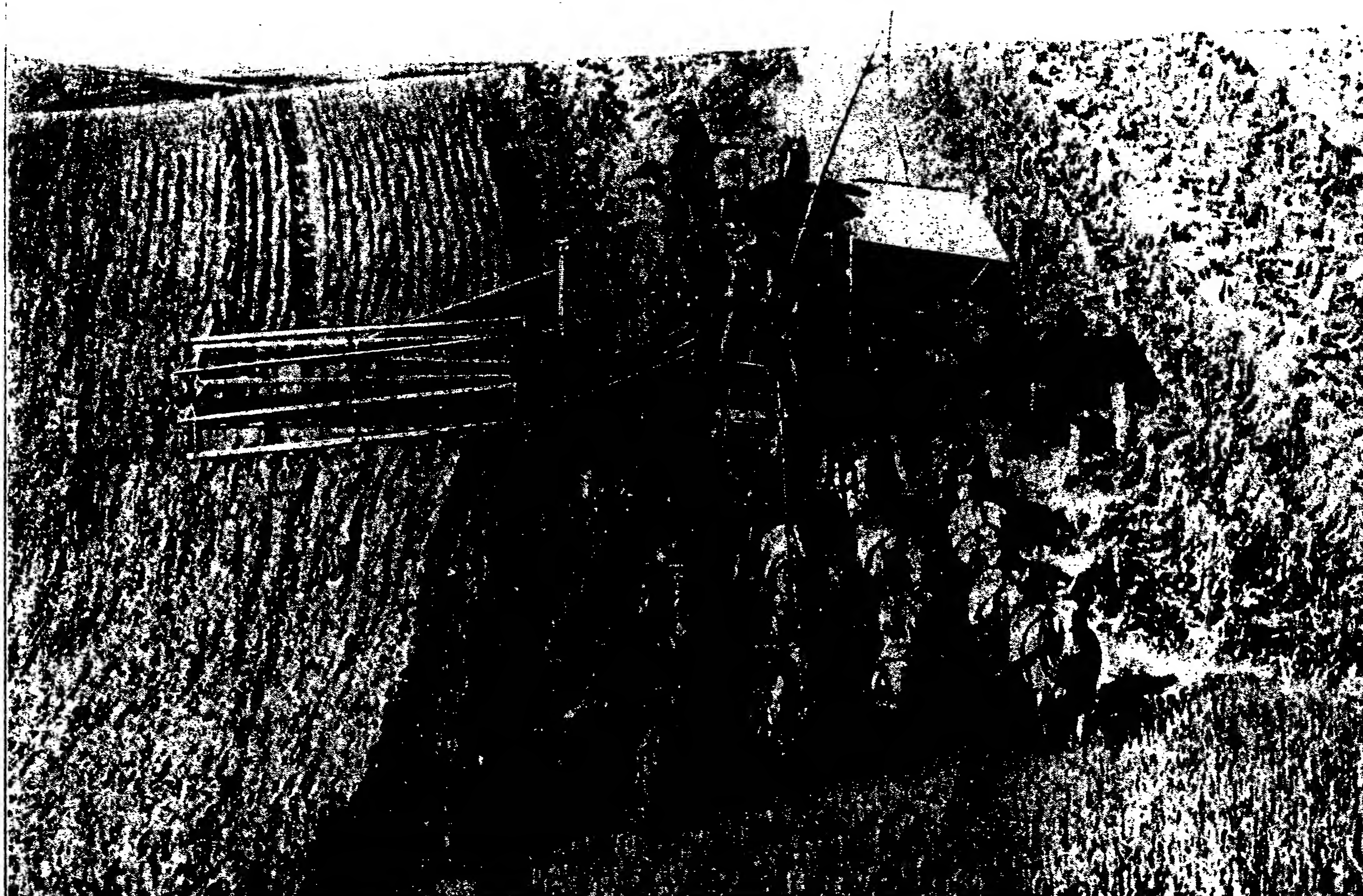
1. $\frac{4c}{9a^2b}$.
2. $\frac{2a^4x}{5b^2y}$.
3. $\frac{a}{b}$.
4. $\frac{x-1}{x}$.
5. $\frac{x-3}{x+5}$.
6. $\frac{x-7}{x-6}$.
7. $\frac{1+a^2}{2+a^2}$.
8. $\frac{3a(a+3)}{2b(a+1)}$.
9. $\frac{(x-2)(x+3)}{x^2-1}$.
10. $\frac{4x+3}{3x^2-5x+7}$. [H.C.F. $= 2x^2 - 4x - 1$.]

Examples 24

1. $-\frac{4xy}{x^2-y^2}$.
2. $\frac{14x}{1-9x^2}$.
3. $\frac{4x+1}{(x+1)^3}$.
4. $\frac{x^2+y^2}{x^2-y^2}$.
5. 3.
6. $\frac{3}{a(a+1)}$.
7. $\frac{6+2x^4}{1-x^8}$.
8. $\frac{6x(x^2-2y^2)}{x^4-5x^2y^2+4y^4}$.
9. $\frac{1}{a-2}$.
10. 0.
11. $\frac{3}{9-a^2}$.
12. By reducing each fraction to its lowest terms we get

$$\frac{x}{x+y+z} + \frac{y}{x+y+z} + \frac{z}{x+y+z} = \frac{x+y+z}{x+y+z} = 1.$$

Continued



Underwood & Underwood

THE WHEAT HARVEST IN NORTH-WEST CANADA

Twenty-four horses are dragging a machine that cuts the grain, threshes it, packs it into sacks, and ties the straw into bundles. Such a machine can produce 2,500 sacks of grain in one day

FARMING IN CANADA

The Golden West. Farming, Stock-raising, and Fruit-growing in the Various Provinces of Canada. Government Experimental Stations

continued from page 3002

By Professor JAMES LONG

IT is impossible for an Englishman experienced in agriculture to visit Canada without being impressed with the remarkable results which are being achieved year by year. In no country in the world does the Government provide greater assistance for the promotion of agricultural prosperity. For years past efforts have been made not only to ascertain why the crops over large areas of land have been lamentably small where owing to the character of the soil they should be large, but the farmers have been shown by demonstration at the various experiment stations how to increase the grain produced and the income derived from the production of plant and animal life.

Some General Statistics. The population of Canada reaches nearly 6,000,000, while its area covers nearly 3,750,000 sq. miles. In 1904, the value of the exported produce reached nearly 44 millions sterling, while 45 per cent. of the population are engaged in the cultivation of the soil, and an additional 20 per cent. are either directly or indirectly employed in handling farm produce or in the manufacture of farm implements and machinery. The great bulk of these exports are directly derived from agricultural land, and the products of the timber industry.

In 1904, the Ontario oat crop alone produced 102 million bushels, or 38½ bushels to the acre. The barley crop is increasing both in area and yield; for some years it was practically restricted to 20 million bushels, of which one-half was exported, but owing to the McKinley Tariff, the area was soon reduced, and the crop grown was not more than one-half. At this time, the farmers of the province, under the advice of Government experts, opened up a larger market with Great Britain, producing quantities of cheese, butter, meat, and eggs, with the result that barley was grown on a larger scale than before to feed the stock, and thus, by more intense farming, the average yield was brought up to 31¾ bushels, instead of 21 bushels, to the acre.

The Agricultural Provinces. For the purpose of these remarks, Canada may be divided into the following provinces, agriculturally speaking:

Province.	Area.	Population.	Snow and Rainfall.
	Sq. miles.		Inches.
Nova Scotia ..	20,680	460,000	40 to 45
Prince Ed. Island	2,000	104,000	35 to 40
New Brunswick..	28,000	331,000	44
Quebec	347,000	1,649,000	
Ontario	223,000	218,300	30 to 40
Manitoba ..	73,000	255,000	17½
Saskatchewan and Alberta ..	550,000	500,000	
British Columbia	382,000	177,000	

Although it was only in 1905 that the two new provinces, Saskatchewan and Alberta, were added to the Confederation, the advance which has been made in the North-West and British Columbia may be better estimated if we point out that, while in 1900 the immigrants numbered 49,000, of whom 11,000 were British and 18,000 Americans, the estimated number in 1904 was 180,000. The immigrants from Great Britain in the year ending June, 1905, numbered 65,000, while those from the States had been increased to 43,000. They are practically presented with 160 acres free, and, with a very trifling capital, and the common-sense to learn the ways of the country before they settle, they are ultimately able to achieve happiness and prosperity.

The Wonderland of the World. Canada is one of the few countries of the world which possess huge areas of rich land capable of growing grain and other crops without manure for a long series of years. As we shall see, there are many districts in which, in spite of the general severity of the winter, crop growing and stock raising can be conducted through a large portion of the year.

Dairying and fruit growing are becoming general in almost all parts of the country, while on the Pacific Coast and in various districts of British Columbia, the settler possesses great advantages for the pasturage of cattle. According to Dr. Saunders, the chief of the experimental stations, and one of the ablest and safest of advisers, the main elevation of Canada is 300 ft. above sea-level, as compared with 671 ft. in Europe; while the diversity of soil, of plant, of mountain, valley, and lake, rolling prairie and forest land, is easily recognised by the traveller from Halifax to the Pacific Coast, a distance of more than 3,500 miles.

Value of Experiment. The Dominion offers great advantages through its five experimental farms, its agricultural colleges and schools—the chief of which is at Guelph, in Ontario—its dairy schools, travelling dairies, farmers' institutes and associations. The Government have established cold storage to assist in the export of perishable goods, and expended large sums in experiment and demonstration, not only at the great Central Farm at Ottawa, but those in Nova Scotia, Manitoba, Assiniboia, and British Columbia. Plants from all parts of the world have been grown with the object of testing their value to the Canadian farmer, while cross-breeding is practised for the same purpose, and the feeding of livestock for the production of meat and milk is conducted on experimental lines. Thousands of samples of seed of important varieties are sent out from Ottawa year by

year without charge, with the result that the farmers, having tested and found the increased value of certain varieties, are induced to employ them extensively, and to profit by the results. To give an example, it may be pointed out that as the result of experiment wheat sown at intervals of a week showed that a delay of one week after the time when it ought to be in the ground involved an average loss of 30 per cent. of the crop, while a delay of two weeks involved a loss of 40 per cent., three weeks of 50 per cent., and four weeks of 56 per cent.; and so it is with oats, barley, and mangels.

Advantages and Disadvantages. Thus it is that the climate plays such an important part in the farmer's work; he has, however, the soil to help him, for it is rich in almost all the agricultural districts of the Dominion. Taking the averages resulting from the work at the Central Farm, it has been found that in the top foot there are 7,700 lb. of nitrogen per acre. Assuming this to be all available, it is sufficient to produce 150 very large crops of grain. Taking the average at the same depth, there are 5,400 lb. of phosphoric acid, enough for 250 large crops, and 11,700 lb. of potash, sufficient for 300 crops. It follows, therefore, that by good cultivation and by sufficient care in the employment of manure, the farmer who takes up land in Canada may look for heavy crops with but little trouble to himself, and leave behind him a heritage which will serve his successors for generations. The Commissioner of Agriculture points out the following difficulties that confront the farmer:

1. Those that arise out of the growing of crops. (These are becoming greater every year from the partial exhaustion of the soil, from the increasing prevalence of weeds, and from the more vicious and general attacks of insects and fungus pests.)

2. Those that come from the necessity of meeting the demands of markets for better qualities in everything.

3. Those which grow out of the changed conditions of life, and which require the farmers to carry on more varied, mixed, or diversified classes of farming. (These come from the growth of population in cities and towns; from the people becoming better off and more fastidious and exacting in their tastes; and through cold storage giving them an opportunity to market perishable things abroad.)

4. Those which have come with low prices for general farm products, and which are beyond the control of the people of this country.

5. Those that are inseparable from maintaining the fertility of soil economically.

All these difficulties are more or less easily overcome where the principles of agriculture have been mastered.

Nova Scotia

A large portion of this province is covered with timber; although it contains 20,000 square miles, the population of nearly 500,000 is largely engaged in agriculture and stock breeding, cultivating the fertile soils between the ranges of hills with considerable success. The hay crops are large, and form the chief article of produce; the soil is occasionally broken up, however, and sown with oats; wheat, barley, rye, peas, and buckwheat are also grown, together with turnips and potatoes.

The rainfall varies from 40 to 45 in., while the climate, although variable, sometimes in the extreme, is temperate in relation to the latitude.

The production of livestock, chiefly cattle, sheep, and pigs, is considerable, but there is immense scope for an increase in this direction, and the consequent production of much larger quantities of manure, which would contribute to the increase of the crops.

Butter and cheese factories have been established during the past few years with success, while fruit growing is developing still more rapidly, especially in those valleys in which the position, soil, and climate are suitable for the production of the best apples, pears, and stone fruit. Apples in particular enjoy a high reputation. The annual export for some years past has reached 500,000 barrels, but a large increase may be expected, owing to the planting of new orchards, which may be extended in many directions on a large scale.

Prince Edward's Island

This island is about 150 miles in length, varying from 9 to 30 miles in breadth. It possesses a moist and mild summer climate, while in winter the temperature never falls to a very low figure.

The crops produced by the farmers, who form some 80 per cent. of the population, include wheat, barley, oats, and buckwheat, hay, potatoes, and turnips, the chief products being hay, oats, potatoes, and turnips.

The crops are not so largely exported as formerly, owing to the advance which has been made in the dairy industry, which is conducted on the co-operative principle. Cheese, in consequence, now forms one of the largest items of the export trade, although butter is being made on an extensive scale during winter. Naturally, owing to the by-products of the butter and cheese dairies, the breeding and feeding of swine has extended.

The farmers raise cattle for beef in excess of their requirements; sheep are largely bred, and horses form an important feature on many farms. The result of this extension is that the crops formerly exported are now consumed, with the result that, while the profits are larger, the land is maintained in better condition. Although fruit-growing does not give the results achieved in some other parts of Canada, the industry is growing, and apples, plums, cherries, and small fruits are easily and abundantly produced.

New Brunswick

Practically one-half of this province is covered with forest and woodland, but although timber has, in the past, formed the most prominent industry, the work of the farmer is destined to obtain the chief place, owing, in part, to the fertile character of the soil and to the good crops which are obtainable where it is well

cultivated. The hay crop is the chief product of the farm, about one-half of the cultivated area, some 1,000,000 acres, being under grass for mowing; the remaining 500,000 acres are chiefly devoted to oats and buckwheat, followed by potatoes, wheat, and barley.

Although the rainfall is sufficiently abundant for crop-producing purposes, the climate is severe in winter, while the summer season is not so hot as in many other parts of the Dominion; indeed, the extremes are not so great.

Stock-rearing on a successful scale is practised, while of late years increasing attention has been devoted to the dairy industry, with the result that there are a considerable number of successful butter and cheese factories.

Owing to the climate, fruit growing has progressed but slowly, but in many cases the industry has found a home, and is, in consequence, steadily progressing, the apple in particular enjoying a good reputation, while small fruits are grown with ease and profit.

Quebec

Like so many other parts of the Dominion, Quebec produces a large quantity of timber, more than half the province consisting of forest and woodland; there are, however, many fertile valleys in which agriculture is conducted by a large proportion of the population with considerable success. In spite of the varied character of the climate in different districts, the crops grow rapidly during the heat of summer, especially hay, which is one of the chief products, and which is largely exported. The extension of the dairy industry, however, is tending to the increase of stock breeding and the larger consumption of the hay crop, as well as of the coarser grain, which is more profitable for milk, butter, and cheese production than for sale.

The chief grain crops are oats and wheat, but barley, rye, maize, peas, buckwheat, potatoes, mangels, turnips and sugar-beets, tobacco and flax are also successfully grown. Much of the soil is extremely fertile, so that, while heavy crops can be produced by good farming, stock can be kept, and be well fed during the cold but bracing winters, when the attention of the farmer is almost entirely concentrated upon it.

In some parts of Quebec the farmers are most successful in breeding horses, while in suitable localities apples, pears, plums, and other fruits are grown with great success, although in other parts the winters are too severe for the ripening of the best varieties.

Ontario

The area of Canada's chief province, Ontario, is 141,000,000 acres, of which, in 1903, 13,643,000 acres were cleared, 6,700,000 consisting of woodland, and 3,500,000 of swamp or marsh. The area devoted to the leading crops and the quantities estimated to have been produced in 1904 are shown in next column.

In addition to the crops shown, 6,000 acres were devoted to carrots, 49,000 acres to rape, 2,250 acres to hops, 6,300 acres to flax, 3,000 acres to tobacco, and 14,000 acres to the culti-

Crops.	Acres.	Bushels.
Wheat (Fall) .	608,458	9,160,623
Wheat (Spring)	225,027	3,471,103
		12,631,726
Barley ..	772,434	24,567,825
Oats ..	2,654,936	102,173,443
Rye ..	130,702	2,001,826
Maize, excludir Maize for food, etc	329,882	20,241,914
Buckwheat	100,608	2,066,234
Peas ..	339,260	6,629,866
Beans ..	50,892	912,849
Potatoes	133,819	15,479,122
Turnips..	133,207	64,861,703
Mangels	71,344	33,595,440
		Tons.
Hay and Clover ..	2,926,207	5,259,189
Maize for fodder ..	193,115	2,023,350
Pasture land	3,183,673	
Orchards and Gardens	369,459	

vation of the vine. The number of livestock in Ontario in 1904 was as follows:

Milch Cows ..	1,078,000	Pigs	1,927,000
Other cattle ..	1,697,000	Horses ..	655,000
Sheep ..	1,455,000	Turkeys, Geese, and Poultry	9,400,000

There are in Ontario no less than 100,000 acres of forest and woodland, the timber trees including oak, ash, elm, the white and red pines, hickory, and walnut.

The districts suitable for agricultural purposes are numerous and extensive, while of the 12,000,000 acres of land which have been cleared no less than 11,000,000 acres are under grass and arable crops. Much of the soil is of excellent quality and highly fertile, while in the south-west of the province the climate is mild. In the districts near the Great Lakes the winters are not very severe, nor the summer season too oppressive.

In addition to the crops which have been enumerated, the farmers of the province produced, in a recent year, to take an average example, clover and alsike seed which covered 189,000 acres.

Fruit Growing. The fruit growing capacity of Ontario is well known, chiefly owing to the large consignments which we receive in this country. The possibilities of production are believed to be unlimited; already the area occupied by orchards and vineyards exceeds 366,000 acres. The planted apple trees number considerably more than 11,000,000, while the apple crop in a recent year reached 37,000,000 bushels, or 5⅓ bushels per tree of bearing age. In a good year, this crop is much exceeded; in 1896, for example, with a much smaller area, the yield was 56,000,000 bushels. Dr. Saunders points out that in one part of Ontario alone the apple country extends to a distance of 288 miles. Grapes, too, are produced in abundance, a large portion of the crop being employed in the production of a native wine. The growth of pears, stone, and small fruits is large, and increasing in all parts of Ontario, while in addition to the export of raw apples, large quantities are dried by evaporation for the general market.

Manitoba

Manitoba is west of and adjoining Ontario, while its position is about central, as between the Atlantic and the Pacific. It chiefly consists of rolling prairies with occasional valleys and rivers, the soil being to an extraordinary extent of a deep, rich, vegetable character, highly fertile, and capable of bearing crops for many years in succession. The proportion of forest and woodland is estimated to reach 40 per cent., but in the chief agricultural districts very little timber is noticeable. The climate is somewhat extreme—warm in summer; cold and invigorating, owing to the dryness of the air, in winter, which commences in November and continues until the end of March or a little later. The precipitation is small, and chiefly deposited between April and October. Although the land available for farm purposes reaches 30,000,000 acres, the area under crop scarcely reaches one-eighth. The farmers commence to sow their seed in April, while they harvest their crops in the month of August, wheat being the most important. The No. 1 hard wheat of Manitoba, like that of the Territories adjoining in the north-west, is unexcelled, and when comparisons were made with the products of other countries exporting to England, the quotations in Liverpool were 4s. 7d. per bushel for No. 1, 4s. 6½d. for No. 2., 4s. 2d. for the best Russian wheat, 4s. 1d. for Argentine, and 3s. 9d. for Indian. In Manitoba the oat crop reached 38⅞ bushels in a recent year, but, as in Ontario and elsewhere, the higher yield is chiefly owing to the special use of the Banner variety, which at almost all the experimental stations produced more bushels per acre than any other variety under test. The result of this form of success has been that the oat crop in 1904 was four times as large as in 1900.

Long Hours of Work. Certain friends of the writer, who are engaged in mixed farming in the Province, some years ago abandoned the practice of wheat growing alone, and have since produced milk and pork for the butter and bacon factories with great success, feeding their stock upon their own produce, which, having sown the seed, they reap themselves at little expense, undergoing an amount of labour in the pursuit of their industry which is practically unknown to workmen on the British farm. Canadian farming provides an incentive to work long hours, and to rely upon one's own efforts, which has possibly never been contemplated by the English farmer or the labourer whom he employs. The climate of Manitoba is too severe for the production of the best kinds of fruit. The growth of garden produce of other kinds, however, is easy; the potato, pulse, plants of the cabbage tribe, rhubarb, maize, tomatoes, and small fruits are all grown with success, although tomatoes require the aid of glass. In Manitoba the estimated quantities of grain produced in 1904, including rye, peas, and maize, were 86,750,000 bushels, these crops being grown upon 3,730,000 acres, in addition to which 3,800,000 bushels of potatoes were grown upon 24,000 acres, 464,000 bushels of flax on 35,000 acres, and 3,750,000 bushels of roots on 14,000 acres. In the same year Manitoba possessed 143,000 horses, 306,000 head of cattle, 18,000 sheep and 118,000 pigs. The total area is 41,169,000 acres.

Saskatchewan and Alberta

In the north-west territories, which include Assiniboia and Alberta, the crops and produce in 1904 were as follows:

Crops.	Acres	Bushels.
Wheat (Spring)	957,253	16,723,412
Wheat (Fall) ..	8,296	152,125
Barley	86,154	2,205,434
Oats	523,634	16,335,519
	1,575,337	35,416,490

In addition, 16,000 acres were devoted to flax, which produced 170,000 bushels. The number of livestock in these Provinces in 1901 consisted of 591,000 cattle, 176,000 horses, 154,000 sheep, and 73,000 head of swine. The comparatively low average of production in Manitoba and elsewhere in oats, wheat, and potatoes is chiefly the result of bad workmanship on the part of a number of farmers, who do not act upon the lessons which the Government are teaching them. The best farmers, however, like the directors of the Government farms themselves, are able to grow an average of 50 to 60 bushels of oats and from 300 to 400 bushels of potatoes. In experimental fields, however, as many as 500 bushels have been grown, while the oat crops have reached 115 bushels to the acre. The success of the oat crops on the soils of Manitoba is remarkable where cultivation is clean and practical, especially in view of the fact that larger yields are obtained by the employment of 2 to 2½ bushels of seed, instead of 4 to 5 bushels, as is common in this country.

British Columbia

This province is clothed with high mountains and fertile valleys exhibiting considerable climatic variations and great productive powers. In those districts suitable for agriculture, stock raising, and fruit growing, the climate between the mountain ranges and the coast is mild and closely resembles that of many parts of the British Isles. In some parts of the province the rainfall is deficient, with the result that irrigation is necessary, but the soil is rich and well adapted to productive purposes in many valleys. The further we get from the sea, the more severe the climate—the greater the warmth in summer and the cold in winter. According to Dr. Saunders, the rainfall reaches 67 in. at the experimental farm of Agassiz, which is about 70 miles east of Vancouver. The chief crops are hay and oats, followed by potatoes, roots, barley, and wheat, while hops and flax are also grown with success. Stock rearing is not extensive, but good dairy herds are becoming more general, and butter-factories are prosperous. There is an immense area of land adapted to the cultivation of apples, pears, plums, and cherries, while smaller bush fruits and strawberries are easily grown.

Continued

SPANISH—ITALIAN—FRENCH—GERMAN

Spanish by Amalia de Alberti; Italian by F. de Feo; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

Continued from page 3064

SPANISH

Continued from page 30[illegible]8

By Amalia de Alberti

Relative Pronouns. These are as follow:

QUE, who, which, that. QUIEN, who.
CUAL (used with definite article), who, which.
CUYO, whose, of which, which.

1. QUE is invariable in gender and number, it relates to persons in the nominative and accusative only, and to things in all cases.

Examples: *El hombre que cantó*, The man who sang. *Las cosas de que hablamos*, The things of which we speak.

QUIEN, plural QUIENES, relates to persons only, and is invariable in gender. The accusative *whom* is rendered by *á quien* or *que*. Examples:

El hombre á quien mataron, El hombre que mataron, The man whom they killed.

Los hombres á quienes mataron, The men whom they killed.

NOTE. The relative pronoun is never omitted in Spanish in such cases. "The men they killed" would be incorrect.

2. CUAL, plural CUALES, is invariable in gender. It relates to persons and things, and is generally accompanied by the definite article agreeing with the antecedent. It is substituted for *quien* and *que*. Examples: *Han escrito una carta la cual recibí*, They have written a letter which I have received. *Tenemos un amigo, el cual vive en la casa de enfrente*, We have a friend, who lives in the house opposite.

Cual is used without the article to express comparison; in such cases it is often preceded by *tal*, and may be translated, *as, like, such as.*

Examples: *Una mujer cual se puede admirar*, A woman such as one can admire. *Hay que sufrir la pena tal cual viene*, Suffering must be endured, such as it comes. *Cual un angel de Dios*, Like an angel of God.

Cual is also used without the article in sentences of interrogation or doubt. Examples:

¿No sé cual de los libros es mio, I do not know which of the books is mine. *¿Cuál de los dos prefiere Vd?* Which of the two do you like best?

Lo cual is the neuter form and has a phrase or sentence for its antecedent. Example: *Le dijo algo, lo cual no escuché*, He said something to me to which I did not listen.

Que is also used with a definite article in the same way as *cual*; *el que*, he who, *la que*, she [illegible] etc. [illegible] *ayer*, [illegible] who spoke to us yesterday. *Estas sillas son las que necesitamos*, These chairs are those which we want.

3. CUYO, fem. CUYA, whose, of which, which relates to persons or things and agrees in gender and number with the object possessed. Examples: *La muchacha cuya belleza se admira*, The girl whose beauty is admired. *Los reos cuyos crimenes se han de castigar*, The criminals whose crimes must be punished.

All these relative pronouns take an accent when used interrogatively. Examples:

¿Qué dice? What does he say? *¿Quién es?* Who is it? *¿Cuáles de los libros quiere Vd?* Which of the books do you want?

The use of *cuyo*, whose, as an interrogative is inelegant; it should be rendered by *de quien*, of whom. Examples: *¿De quién son esas casas?* Whose houses are those?

Indefinite Pronouns. The indefinite pronouns are as follow:

ALGUIEN, somebody, someone, anybody, anyone; invariable, relating to persons only.

ALGUNO, somebody, etc., some; variable in gender and number, relating to persons and things.

ALGO, something; invariable.

NADIE, nobody, no one; invariable.

NADA, nothing; invariable.

NINGUNO, nobody, no one, none; relating to persons and things, variable in gender and number.

QUIENQUIERA, whoever, anyone, whatever; relating to persons only; invariable.

CUALQUIERA, plural CUALESQUIERA, whoever, anyone, whatever; relating to persons and things; invariable in gender.

TODO, all; variable in gender and number, relating to persons and things.

OTRO, other, another, variable in gender and relating to persons and things; it can never be used with the indefinite article.

Vocabulary	Vocabulario
A civilised man	Un hombre civilizado
A savage	Un salvaje
An uncouth man	Un hombre soez
A courteous man	Un hombre cortés
A man of knowledge	Un hombre de saber
A man of science	Un hombre de ciencia
A man of power	Un hombre de poder
A good woman	Una buena muger
An honourable woman	Una muger honrada
A studious young man	Un joven estudioso
A collegian	Un colegial
A student	Un estudiante
A medical student	Un estudiante de medicina
A collegian (f.)	Una colegiala
A student (f.)	Una estudianta

A criminal	Un criminal
A thief	Un ladron
Capital punishment	La pena capital
Condemned to death	Condenado á muerte
To hang	Ahorcar
Hanged	Ahorcado
The guillotine	La guillotina
The gallows	El patíbulo
A visit	Una visita
A saleswoman	Una vendedora
A woman of little worth	Una mujer que vale poco
A man of bad life	Un hombre de mala vida
A gambler	Un jugador
A contractor	Un contratista
The Stock Exchange	La bolsa
An engineer	Un ingeniero
A farrier	Un herrero
A gunsmith	Un armero
An artisan	Un artesano
A bricklayer	Un albañil
A stonecutter	Un picapedrero
A whitewasher	Un enjalbegador
An architect	Un arquitecto
A forger	Un falsario
A falsifier	Un falsificador
A preacher	Un predicador
A drunkard	Un borracho
A drinker	Un bebedor
A liar	Un mentiroso
An assassin	Un asesino
A volunteer	Un voluntario
A telegraph clerk	Un telegrafista
Telegraph	Telégrafo
A telescope	Un telescopio

Exercise IX. (1).

Translate the following into Spanish:

1. That woman came like an angel of God.
. . . . vino . . . .
2. Who sang? No one sang. 3. Someone came this morning. 4. Someone has told me.
. . . . . . mañana . . . .
5. There is something to say. 6. He told me
. . . . decir . . . .
nothing. 7. No one knows the criminal. 8. Whoever said this is a liar. 9. He is a nobody;
. . . . cualquiera
anybody can see it. 10. All speak English. 11. Another admiral and another frigate. 12. That man is uncouth, but that other is courteous. 13. That man was condemned to death. 14. They do not trust that woman, she is of little
. . . . se fian . . . .
worth. 15. That collegian is studious. 16. That man is a medical student, and will be
. . . . será
a good doctor. 17. The criminal was hanged
. . . . fué . . . . .
this morning.

Exercise IX. (2).

Translate the following into English:

1. ¿ Quién ha escrito la carta ? 2. ¡ Qué desgracia ! 3. ¿ A quién debe Vd dinero ? 4. Los hombres á
. . . . owe . . . .
quienes mataron lo merecian. 5. ¿ Cómo le gusta
. . . . deserved . . . .
á Vd esa mujer ? Vale poco. 6. Tal cual fué su mala vida, tal fué su muerte. 7. El criminal fué ahorcado. 8. El albañil y el enjalbegador han llegado. 9. El falsario eraunmentiroso. 10. El
arrived . . . .
arquitecto estaba borracho. 11. El armero tiene mi fusil.

PROSE EXTRACT VII.

From "Diario de un Testigo de la Guerra de Africa" ("Diary of an Eye-Witness of the War in South Africa"). By Pedro Antonio de Alarcon.

The Effects of Military Service.	Los Efectos del Servicio Militar.
The peaceful habits and customs of the city, the necessities of a pampered existence are fading from our memories and dying out of our minds, giving place to other customs, other habits, other necessities and other interests.	Las costumbres pacíficas los hábitos de la ciudad, las necesidades de una existencia regalada van desvaneciéndose en nuestra memoria y amortiguándose en nuestra mente, cediendo su puesto á otras costumbres, á otras hábitos, á otras necesidades y preocupaciones.
War becomes incarnate in us, identifies itself with our being, and constitutes our character. For myself it seems to me that I was born in it, and I find its hardships and discomforts quite natural. Morning and evening would now seem strange to me without the sound of Reveille and Retreat. The tent is a matchless dwelling, the bed no longer seems hard to me, the food could not be more appetising. To go to bed at ten is to be up all night; he who does not see the sunrise is no early riser. To sleep without undressing has its advantages.	La guerra encarna en nosotros, se identifica con nuestro ser, constituye nuestro carácter. Yo mismo creo haber nacido en ella, y encuentro muy naturales sus molestias é inconvenientes. Ya no comprenderia un amanecer sin toque de diana, ni un anochecer sin toque de retreta. La tienda es una casa inmejorable; el lecho ha dejado de parecerme duro; la comida no puede ser mas apetitosa. Acostarse á las diez es trasnochar; el que no ve salir el sol, no madruga. No desnudarse para dormir tiene sus ventajas.
When we hear that a friend of ours has been	Cuando se nos dice que un amigo nuestro

wounded, it has the same effect upon us as it would have had formerly to hear that he had lost at cards. "Is it much?" we ask, and think no more about him.

To die is equivalent to going on a journey. *So-and-so is dead,* is the same as to say, *So-and-so has left Africa. What! I am very sorry . . . he was a good fellow. We shall get along without him.* This is the kind of sorrow caused by such news, the funeral panegyric and oration which accompanies those who die.

Going into action is like going to the bull-fight; to assemble in a tent and talk is a pleasure as sweet as ball or opera; to come upon the corpse of a Moor in a field surprises one no more than if it were a favourite flower; not to sleep in a pool of water is the *ne plus ultra* of comfort.

Thus, we live at the wars as in our element; a thousand futile joys and puerile pleasures occupy our days; our necessities have reduced themselves to the level of our resources for their gratification, and now, as ever, cheerfulness has followed resignation.

Pedro Antonio de Alarcon (1833-1891), very popular as a writer of short stories, some of which have been translated into English. Alarcon was also distinguished as a journalist, and acted as war correspondent to "La Iberia" during the war in Morocco in 1859. The above extract is taken from his vivid account of the campaign, written in the form of letters to that paper, and afterwards published in book form.

ha sido herido, nos produce el efecto que nos hubiese causado ántes oir decir que habia perdido al juego. "¿Es mucho?" se pregunta, y no se vuelve, á pensar en él.

Morir equivale á viajar. *Fulano ha muerto,* es como si se dijera. *Fulano se ha ido de Africa. ¡Hombre! lo siento . . . era buen chico . . . Nos pasaremos sin el.* Hé aqui el género de pena que causa esta noticia; el elogio funebre y la oracion que acompañan á los que mueren.

Entrar en acción es como ir á los toros; reunirse en una tienda á hablar, un placer tan dulce como un baile ó una ópera; ver en un campo un cadáver moro, le sorprende á uno como si encontrase una flor de su gusto; no dormir en un charco de agua, es el *ne plus ultra* de la comodidad.

Vivimos, pues, en la guerra como en nuestro elemento; mil fútiles goces y pueriles placeres ocupan nuestros dias, nuestras necesidades se han reducido al nivel de los medios de satisfacerlas, y la alegría, ahora como siempre, ha venido en pos de la resignacion.

Pedro Antonio de Alarcon (1833-1891), muy popular como escritor de cuentos, de los cuales algunos han sido traducidos al inglés. Alarcon fué tambien distinguido como periodista, sirvió como corresponsal en la guerra de Marruecos en 1859, para "La Iberia." El extracto dado mas arriba es tomado de su brillante relación de la campaña, escrita en forma de cartas para este periodico, y despues publicadas en forma de libro.

Key to Exercise VIII. (1).

1. Este gaban es mio, y este vestido es tuyo.
2. Estas flores son mias, estos libros son tuyos.
3. Salvé mi vida con un salvavidas.
4. Tus manos están limpias. Su cara es bonita.
5. Su vida de Vd es trabajosa.
6. Dios guarde á Vuestra Majestad.
7. Amigo mio está nevando, no se puede salir.
8. Querido amigo mio, no temo la nieve.
9. Unos vecinos nuestros han sido matados por unrayo.
10. Aquel niño está enfermo.
11. Un cohete cayó sobre aquella mujer.
12. Esas nubes oscurecen el cielo.
13. Esa es agua del mar.
14. Aquel hombre mató á su hermano—esto es lo que me han dicho; no lo creo.

Key to Exercise VIII. (2)

1. I do not care what they have said.
2. That which they have said is not the truth.
3. That is mine; it is my hat and my book.
4. Those men are good.
5. My dog is in the house with that man.
6. This house, and that church are mine.
7. This is bad, and that is good.

Continued

ITALIAN

Continued from page 3060

By Francesco de Feo

Modification of Substantives and Adjectives

The original simple meaning of substantives and adjectives may be altered by the addition of suffixes, which generally convey an idea of diminution (diminutives) or increase (augmentatives)—*e.g.*, *libro*, book; *libretto*, small book; *librone*, large book.

The idea of diminution often implies prettiness, gentleness, etc., but sometimes contempt—*e.g.*, *librettino*, a pretty little book; *libercolo*, a valueless little book. The idea of increase often implies rudeness and coarseness—*e.g.*, *libràccio*, a large, ugly book; *stanzàccia*, an ugly large room.

Diminutive Suffixes. The diminutive suffixes most frequently used are:

1. -Ino, -icìno (*eèno*, *ee-cheè-no*). Examples: *ragazzo*, boy, *ragazzino*, little boy; *mano*, hand, *manina*, a pretty little hand; *lume*, lamp, *lumicino*, a little lamp. Nouns ending in *-one* take the termination *cino*—*e.g.*, *bastone*, stick, *bastoncino*, an elegant little stick; *bottone*, button, *bottoncino*. The termination *ino* is also used to denote a younger member of the family, as:

padrone, master, *padroncino ; principe*, prince, *principino*.

2. ELLO, ERELLO, CELLO (*èhllo, ehrèhllo, chèllo*) are mostly used with substantives—*e.g.*, *fuoco*, fire, *focherello*, a nice little fire ; *fatto*, story, *fatterello*, a little story ; *fiume*, river, *fiumicello*, a little river; *bastone*, stick, *bastoncello*, a common little stick.

3. ETTO. Examples: *casa*, house *casetta*, a pretty little house; *fìschio* (*feèsheeo*), whistle, *fischietto*, a little whistle ; *sèmplice*, simple, *semplicetto*, rather simple.

4. OTTO, ACCHIOTTO (*ahckeeòtto*). Examples: *giòvine*, young, *giovinotto*, a smart young man; *vècchio*, old; *vecchiotto*, a fine old man; *grasso*, fat, *grassotto*, rather fat. These terminations denote also young animals: *àquila* (*àhkoo-eelah*), eagle, *aquilotto ; orso*, bear, *orsacchiotto*.

5. ÙCCIO, ÌCCIÒLO (*oòcheeo, eèchee-òlo*). Examples: *bocca*, mouth, *boccùccia*, a little beautiful mouth; *strada*, street, *stradicciòla*, a little street; *letto*, bed, *lettùccio*, a small bed.

The termination *ùccio* is also used to express commiseration. Examples: *animale*, animal, *animalùccio*, a poor little animal; *ragazzo*, *ragazzùccio*, a poor little boy.

6. UZZO, OLO, ÙCOLO (*oòtso, oòcolo*) are often used to express contempt—*e.g.*, *faccenda* (*fahchèhndah*), affair, *faccendùzza*, a small household affair ; *poeta*, poet, *poetùcolo*, poetaster ; *mèdico*, physician, *medicùzzo*, "an ass of a doctor."

Augmentative Suffixes. The augmentative suffixes most frequently used are :

1. ONE. Examples : *Uomo*, man, *omone*, a big man ; *carrozza*, carriage, *carrozzone*, a great ugly carriage ; *dottore*, doctor, *dottorone*, a great doctor. Feminine substantives become masculine. Masculine substantives have a feminine in *ona*. Examples: *bèstia*, beast, *bestione* (m.); *fanciullo*, child, *fanciullone* (m.), *fanciullona* (f.).

2. AZZO, -ACCIO, -ASTRO (*àhtso, àhccheeo, ahstro*) imply contempt. Examples: *roba*, goods, *robàccia*, rubbish ; *uomo*, man, *omàccio*, an ill-bred man ; *donna*, woman, *donnàccia*, virago; *giovine*, young, *giovinastro*, a dissolute young man ; *amore*, love, *amorazzo*, intrigue. The termination *-accio* with adjectives expresses also commiseration : *povero*, poor, *poveràccio*, poor man. The termination *astro* signifies also likeness, but always with a sense of depreciation : *verde*, green, *verdastro*, of an ugly greenish colour ; *giallo*, yellow, *giallastro*, of an ugly yellowish colour.

3. AGLIA (*àhleeah*). Examples: *ciurma*, crowd, *ciurmàglia*, rabble ; *plebe*, plebeians, *plebàglia*, mob ; *gente*, people, *gentàglia*, roughs.

NOTE. No absolutely fixed rules exist respecting the formation of the diminutives and augmentatives. Some words form many, some few, some none. The various shades of meaning are to be learned only from use. With the very common ones the student will easily become acquainted ; the others he may very well leave until he becomes a little proficient in the language, as it is quite possible to be understood without employing them, and by using the adjective as in English—for example, instead of saying *libretto*, little book, saying *piccolo libro*.

CONVERSAZIONE.

Vi piàcciono questi fiorellini ?

Si ; sono belli, ma i fiori del nostro giardino sono molto più belli.

Dove avete passato l'estate ?

In campagna ; non mi piace la vita di città.

Avete ragione ; la vita di campagna è molto più piacèvole.

Com' è questo vino ?

Il vino non è così cattivo come l'altro, ma la birra è pèssima.

Chi è questa ragazzina ?

È la figlia minore di quel buon vecchietto.

È tanto carina, ma è un po' malatùccia ; poverina, ha le manine fredde fredde.

A che ora avete appuntamento con la vostra cuginetta ?

Alle otto, dobbiamo aspettare (we must wait) ancòra un' oretta.

Tanto mèglio, avremo tempo di fumare (to smoke) una sigaretta e di fare una passeggiatina nel parco.

THE VERB

The Italian verbs end in the infinitive with the syllable *-re*. This syllable is preceded by the vowels *-a, -e, -i*, which are called *characteristic vowels*. By these three vowels three conjugations of verbs are distinguished.

First conjugation in *-a-re*, as : *parlare* (*pahr-làh-reh*), to speak.

Second conjugation in *-e-re*, as : *crèdere* (*crèh-deh-reh*), to believe.

Third conjugation in *-i-re*, as: *vestire* (*veh-steè-reh*), to dress.

The tenses of the verbs are formed with the following terminations :

Imperfect of the Indicative: *-vo, -vi, -va, -vàmo, -vàte, -vano*. (Pronounce : *vo, vee, vah, vàh-mo, vàh-te, vahno.*)

Imperfect of the Subjunctive : -ssi, -ssi, -sse, -ssimo, -ste, -ssero. (Pronounce : *ssee, ssee, sseh, ssee-mo, steh, ssehro.*)

Future of the Indicative : -rò, -rai, -rà, -rèmo, -rète, rànno. (Pronounce : *rò, ràh-ee, ràh, rèh-mo, rèh-teh, ràh-nno.*)

Present of the Conditional : -rèi, -rèsti, -rèbbe, -rèmmo, -rèste, -rèbbero. (Pronounce : *rèh-ee, rèhstee, rèhbbeh, rèhmmo, rèhsteh, rèhbbehro.*)

The above terminations are the same for the verbs of all three conjugations, and are added to the infinitive without the syllable *-re*. The verbs in *-are*, in the future and in the conditional, change the *characteristic vowel a* into *e*. To simplify this we may say that the terminations for the future indicative and the present conditional of the verbs of the first conjugation are:

Future Indicative : -erò, -erài, -erà, -erèmo, -erète, -erànno.

Present Conditional : -erèi, -erèsti, -erèbbe, -erèmmo, -erèste, -erèbbero.

They are added to the infinitive without the termination *-are*.

Present Indicative.

For the verbs in -(are): *-o, -i, -a, -iàmo, -àte, -ano.*

For the verbs in -(ere): *-o, -i, -e, -iàmo, -ète, -ono.*

For the verbs in -(ire): *-o, -i, -e, -iàmo, -ìte, -ono.*

Pronounce: *o, ee, ah, eh, ee-àhmo, àhtch, ehteh, eèteh, ahno.*

Past Definite.

For the verbs in -(are): *-ài, -àsti, ò, -àmmo, -àste, -àrono.*

For the verbs in: -(ere): *-èi, -èsti, -è, -èmmo, -este, -èrono.*

For the verbs in -(ire): *-ìi, -ìsti, -ì, -ìmmo, -ìste, ìrono.*

Pronounce: *àh-ee, àhstee, ò, àhmmo, àhsteh, àhrono; èh-ee, èh-stee, èh, èhmmo, èhsteh, èhrono; eè-ee, eèstee, eè, eèmmo, eèsteh, eèrono.*

The verbs in -ere may also have the terminations: *-ètti, -èsti, -ètte, -èmmo, -èste, -èttero.*

Pronounce: *èh-ttee, èhstee, èhtteh, èhmmo, èhsteh, èhtteh-ro.*

Present Imperative.

For the verbs in -(are): -, *-a, -i, -iàmo, -àte, -ino.*

For the verbs in -(ere): -, *-i, -a, -iàmo, ète, -ano.*

For the verbs in -(ire): -, *-i, -a, -iàmo, ìte, -ano.*

Present Subjunctive.

For the verbs in -(are): *-i, -i, -i, -iàmo, -iàte, -ino.*

For the verbs in -(ere) and -(ire): *-a, -a, -a, -iàmo, -iàte, -ano.*

	Gerund.	*Present Part.*	*Past Part.*
-(are):	*-àndo*	*-ànte*	*-àto, -a, -i, -e*
-(ere):	*-èndo*	*-ènte*	*-ùto, -a, -i, -e*
-(ire):	*-èndo*	*-ènte*	*-ìto, -a, -i, -e*

The above terminations are added to the infinitive without *-are, -ere, -ire.*

KEY TO EXERCISE XVII.

1. Peter is as good as Charles. 2. I have as much money as you. 3. My father is richer than your friend. 4. That watch is dearer than that chain. 5. The dog is more faithful than the cat. 6. Winter is much colder than autumn, and spring is much less warm than summer. 7. These houses are more high than broad. 8. Yesterday it was cold, but to-day it is much colder. 9. If to-morrow is warmer we will all go and take a walk into the country. 10. This street is too long, the other is much shorter.

KEY TO EXERCISE XVIII.

1. This music is very beautiful. 2. Dante is the greatest poet of Italy. 3. This is the most beautiful page of our history. 4. The greatest debt is a benefit received. 5. The poor are often happier than the rich. 6. If you have spent all your money, so much the worse for you. 7. Steel is harder than iron. 8. We are very much satisfied with our studies. 9. The boys have studied all day. 10. So much the better; the more they study, the more they learn. 11. It is better not to speak of certain things. 12. That girl is very beautiful; she has very black eyes, and hair as fair as gold. 13. My youngest brother is at college, he is a very intelligent boy; he is the best of all the pupils. 14. Do you like my new suit? 15. I do not like it much, it is too light; my suit is much darker. 16. I live very far off, but our friend lives much farther off. 17. Often the remedy is worse than the evil.

Continued

FRENCH

Continued from page 3032

By Louis A. Barbé, B.A.

USES OF THE TENSES

Indicative Mood

1. The PRESENT OF THE INDICATIVE is used to express: (*a*) An action which is taking place at the moment of speaking: *Je vois qu'il pleut,* I see that it is raining. (*b*) An action that habitually takes place: *Je le vois tous les jours,* I see him every day.

2. In French there is no "periphrastic," or "progressive" form of the present. "I am writing," "we are reading," etc., must be rendered by the simple present, *j'écris, nous lisons.*

3. After *si* (if) the present indicative is used both of present and of future action:

S'il pleut nous ne pouvons pas sortir, If it is raining we cannot go out.

S'il part demain je vous le ferai savoir, If he starts to-morrow I shall let you know.

4. A special use of the French present, instead of the English perfect, is to express an action begun at a past time, and continuing up to the present. In this construction it requires either *depuis* or *il y a . . . que.* With *depuis* the order of the words is, first the verb, next *depuis,* and finally the expression of time:

Nous sommes ici depuis trois semaines, We have been here for (the last) three weeks.

Je vous attends depuis dix minutes, I have been waiting for you for (the last) ten minutes.

5. *Il y a* begins the sentence, and is followed by the expression of "time how long," then by *que,* and lastly by the verb:

Il y a trois semaines que nous sommes ici, We have been here for three weeks.

Il y a dix minutes que je vous attends, I have been waiting for you for ten minutes.

6. With "point of time since when" *depuis* only can be used:

Nous sommes ici depuis le premier août, We have been here since the 1st of August.

7. When the expression of "time since when" is identical with an expression indicating the time of day, *il y a* must be used to avoid ambiguity.

Je vous attends depuis une heure means "I have been waiting for you for the last hour"; but it also means, "I have been waiting for you since one o'clock." When the former meaning is intended, it is therefore better to say, *Il y a une heure que je vous attends.*

8. The Imperfect Indicative is used to express what was taking place when something else took place: *Je lisais quand vous êtes entrés,* I was reading when you came in.

It is also used to express what used to take place: *L'année dernière je le voyais tous les jours,* Last year I used to see him every day.

9. It is the descriptive past tense, and, in a narrative, is used to express attendant circumstances, natural phenomena, manners, customs, etc.

Les rayons de la lanterne éveillaient les insectes et attiraient les phalènes qui venaient en battre la corne de leurs ailes poussiéreuses. Le temps était noir. Un coin de la lune se devinait à peine à travers les crevasses d'un nuage couleur d'encre, The rays of the lantern awoke the insects and attracted the moths, which came and beat against its horn with their dusty wings. The weather was black (lowering). A corner of the moon could barely be traced (lit., guessed) through the chinks of an ink-coloured cloud.

10. The imperfect indicative is used after *si* in hypothetical sentences: *S'il était ici, nous le verrions,* If he were here, we should see him.

11. The imperfect indicative is used in French instead of the English pluperfect to express an action, which, having been begun at a past time, was still going on at a time now also past. In this construction *depuis* or *il y a . . . que* must be used just as they are used in the analogous construction with the present tense:

Il y avait deux ans que durait le siège, Le siège durait depuis deux ans, The siege had lasted for two years.

12. The Past Definite is used to present an action as completely past, and in such a way that the beginning and the end of that action are brought before the mind:

En mil six cent huit, le Français Samuel de Champlain fonda la colonie du Canada, In 1608, the Frenchman, Samuel de Champlain, founded the colony of Canada.

13. The duration of an action is expressed by means of the past definite provided it be considered as a single definite point in past time. When this is the case, the verb is usually modified by an adverb or adverbial phrase of time:

Louis XIV. régna soixante-douze ans, Louis XIV. reigned seventy-two years.

14. The past definite is the tense of historical narrative, and is used to express a succession of actions of which each is complete in itself:

Pythéas de Marseille, vers le milieu du quatrième siècle avant Jésus-Christ, fit un voyage dans le nord de l'Europe, longea les côtes de la Gaule, entra dans la Manche, visita les côtes méridionales et orientales de l'île de Bretagne, détermina la latitude de l'extrémité nord de cette île, et après six jours de navigation parvint à Thulé, au delà de laquelle il ne put naviguer, empêché qu'il fut par d'épais brouillards,

Pytheas of Marseilles, about the middle of the fourth century B.C., made a voyage in the north of Europe, skirted the coasts of Gaul, entered the Channel, visited the southern and eastern coasts of the island of Britain, ascertained the northern latitude of that island, and after six days' sailing, reached Thule, beyond which he could not sail, being prevented by dense fogs.

In the following passage, the change from past to imperfect illustrates the difference between the narrative and the descriptive tense, between that which expresses transition from one state to another, and is used for successive actions, and that which expresses state or condition at a certain moment, and is used for simultaneous actions:

La lune se leva derrière la redoute de Cheverino. . . . Elle était large et rouge comme cela est ordinaire à son lever. Mais ce soir-là elle me parut d'une grandeur extraordinaire. Pendant un instant la redoute se détacha en noir sur le disque éclatant de la lune. Elle ressemblait au cone d'un volcan au moment de l'éruption. Un vieux soldat, auprès duquel je me trouvais, remarqua la couleur de la lune. "Elle est bien rouge," dit-il . . . Cet augure m'affecta. Je me couchai, mais je ne pus dormir. Je me levai, et je marchai quelque temps, regardant l'immense ligne de feux qui couvrait les hauteurs au delà du village de Cheverino,

The moon rose behind the Cheverino redoubt. It was broad and red, as is usual at its rising. But that evening it seemed to me of extraordinary size. For a moment the redoubt stood out in black on the bright disc of the moon. It resembled the cone of a volcano at the time of an eruption. An old soldier near whom I happened to be, noticed the colour of the moon. "It is very red," he said. . . . This augury affected me. I lay down, but I was unable to sleep. I got up and walked about for a while, looking at the immense line of fires that covered the heights beyond the village of Cheverino.

15. The Pluperfect Indicative and the Past Anterior of the Indicative are both rendered by the same English form—*viz.*: had + past participle; *j'avais donné* and *j'eus donné* both mean I had given. But the pluperfect merely indicates that, at a point of time now past, an action had already taken place, whilst the past anterior presents one action as immediately preceding another. They are usually preceded by "when," "after," "as soon as," "hardly," "no sooner"—*quand, lorsque, après que, dès que, aussitôt que, ne . . . pas plus tôt . . . que*:

J'avais terminé mes affaires quand vous partîtes, I had finished my business when you went away.

Quand j'eus fini je sortis, When I had finished I went out.

16. The Future expresses that something will take place, and is equivalent to the English "predictive future"—I shall give, thou wilt go, he will write. To express the "promissive future," in which "shall" and "will" are

"notional verbs"—I will speak, you shall go—independent words must be used: *Je veux parler, il faut que vous alliez.*

The future must never be used after *si*, if:

Il nous écrira s'il a besoin de nous, He will write to us if he has need of us.

In English the present frequently occurs instead of the future, after "when," "as soon as," and similar expressions. In French the future must always be used:

I shall speak to him when I see him, *Je lui parlerai quand je le verrai.*

EXERCISE XXIV.

1. Bears (*ours*) climb up (*grimper sur*) trees.
2. The sun shines (*briller*) for everybody (*tout le monde*).
3. The earth refuses (*refuser*) nothing to those who cultivate (*cultiver*) it.
4. Railways have contributed (*contribuer*) to the progress (*le progrès*) of commerce.
5. If he lends you his book do not forget (*oublier*) to thank (*remercier*) him for (of) it.
6. We have been working for more than an hour.
7. He who has not tilled shall not reap (*récolter*).
8. You will regret (*regretter*) not having (to have) spoken to him.
9. They prevented me from entering (*entrer*).
10. Your parents desire that you should work assiduously (*assidûment*).
11. I had been waiting two hours for him when his letter was brought me.
12. The siege (*siège*) of Troy (*Troie*) lasted (*dura*) ten years.
13. If I dared (*le*) I would ask him to lend me twenty francs.
14. He told me (that) he would explain (*expliquer*) that rule to me.
15. When we had finished (*achever*) our work, we went (*allâmes*) and played.
16. I told him yesterday that I should come (*viendrais*) and speak to him to-day.
17. He never meets (*rencontrer*) us without borrowing (*emprunter*) money from us.
18. I would not have given him anything if he had not looked so wretched.
19. Do you think(that) your father will come back (*rentrer*) before twelve o'clock?
20. I wish (*souhaiter*) (that) he may give you what you have asked him (for).
21. The dictionary is on the table; consult it.
22. Beg him to come in.
23. Ask your friends what they think of you.
24. Does your brother speak French as well as you?
25. It is difficult to overcome prejudice.
26. Would your friend dare to speak to them if he were to meet them?

KEY TO EXERCISE XXIII.

Ceux qui méprisent les petits défauts ont bien tort. Le plus petit ennemi est toujours assez grand pour être dangereux. Ce ne sont pas les éléphants qui causent la perte des moissons et la perte des laboureurs; ce sont les sauterelles et les petites chenilles quand le blé est en herbe; les charançons et autres insectes imperceptibles quand il est mûr. Ce ne sont pas les gros voleurs seulement qui dépouillent la treille et le verger de leur fruit, ce sont les petits aussi, les moineaux et même les mouches. Sans être mortels, les petits maux sont quelquefois des ennemis aussi insupportables que les grosses maladies dont nous avons peur. C'est presque toujours par des petits maux négligés que les grands arrivent. Demain le petit rhume d'aujourd'hui sera peut-être une fluxion de poitrine. Sans les petits défauts il n'y aurait pas de vices. D'ailleurs un petit défaut n'est pas une petite chose, et où il y en a un il n'y aura jamais de chef-d'œuvre. Une verrue n'est pas bien grosse, mais si vous l'avez sur le bout du nez, ce sera pour vous une cause continuelle d'ennui et de contrariété. Un petit défaut n'est jamais de petite importance s'il est permanent. Ce qui est durable n'est jamais petit. D'ailleurs un petit défaut est toujours le commencement d'un grand; les vices eux-mêmes sont les enfants des petits défauts. Le petit défaut sera bientôt grand; où il y en avait un il y en aura bientôt plusieurs. Un petit défaut n'est jamais seul. Il a toujours une famille. Si ce n'est point pour lui, c'est pour sa postérité qu'il est à craindre. Vous avez une dent qui a un petit point noir. Ce n'est rien; mais si vous le négligez, ce sera bientôt toute la dent qui sera gâtée. Après celle-là, ce sera la voisine, puis la voisine de la voisine, et le petit point noir que vous avez négligé vous aura coûté plusieurs dents. S'il y a une prune pourrie dans un panier de prunes, toutes les prunes seront bientôt pourries. Le voisinage d'un petit défaut n'est jamais indifférent. La vanité semble être un petit défaut; mais c'est un petit défaut qui a une bien vilaine progéniture. Elle a pour fils le mensonge, qui, malheureusement n'est pas son seul enfant. Elle a en outre deux filles, qui sont la jalousie et l'envie. Parmi leur postérité ils auront la haine, qui sera à son tour la mère de bien des crimes. C'est à cause de leur ténuité même que les petits défauts sont si dangereux. S'ils n'avaient pas l'air si innocents, nous en aurions peur, nous serions sur nos gardes contre eux. Soyez indulgents aux petits défauts de vos amis si vous n'êtes pas à même de les réformer; mais aux vôtres, qui sont toujours sous votre main, soyez implacables.

Continued

GERMAN

Continued from page 3061

By P. G. Konody and Dr. Osten

LIX. COMPARISON OF ADJECTIVES (continued from LV.). In the comparison of predicative adjectives and corresponding adverbs of manner (which are not subject to declension) the superlative is formed with am (contraction of an dem) and aufs (auf das). Some monosyllabic adverbs often add the suffix -ens (spät, late, spät-est-ens; früh, early, früh-est-ens, etc.). Examples: Der Vogel fliegt schnell, the bird flies quickly; der Vogel fliegt schneller, am schnellsten or

Die Sache ist aufs Beste erledigt, the matter is settled in the best way. The adverbs bald, soon, early, and gern, willingly, gladly, form the comparison irregularly:

1. bald, 2. eher, 3. am ehesten.
1. gern, 2. lieber, 3. am liebsten.

1. The comparative of inferiority is formed with the comparatives weniger or minder, less, and nicht so . . . . als, not so . . . . as, which, of course, precede the adjective, adverb, or participle: Die Linde ist schattig, die Pappel ist weniger schattig (or nicht so schattig) als die Linde, The lime-tree is shady, the poplar is less shady than (not so shady as) the lime-tree.

The degree of mutual qualities may also be compared by mehr . . . . als, more . . . . than, and weniger . . . . als, less . . . . than: Das Haus ist weniger hoch, als es breit ist, The house is less high than it is wide.

2. The superlative is generally used with the definite article. The comparative may be used with the indefinite article, but not the superlative: ein jüngerer Sohn, a younger son; der jüngste Sohn, the youngest son.

The definite article is dropped in the form of the English possessive or Saxon genitive, which the German language has borrowed from the English: Die größte Tat Nelsons, the greatest deed of Nelson; but: Nelsons größte Tat, Nelson's greatest deed. The article is also dropped in several adverbial genitives like bestenfalls, in the best case; schlimmstenfalls, in the worst case, etc.; and in names of materials in advertisements, as: bestes Öl, best oil; feinste Seife, finest soap, etc.

The indefinite article is sometimes employed with the superlative if the superiority expressed is absolute. The superlatives allerliebst (in the sense of "most charming") and letzt (last) are absolute, and can therefore be used with the indefinite article: ein allerliebstes Mädchen, a most charming girl: ein letztes Mittel, a last means, etc. The plural is, of course, formed without article: allerliebste Mädchen.

3. As in English there are in German several adjectives which, owing to their definite nature, admit of no comparison whatever. Among them are those which denote certain geometrical forms and materials. A three-cornered object naturally cannot undergo any comparison of superiority, as a higher or lower degree of this quality is excluded: Eisern, of iron; golden, golden; silbern, of silver; steinern, of stone; drei'eckig, triangular; achtzigjährig, eighty years old; künftig, future; doppelt, double; ein-, zwei-, mehrsilbig, mono-, dis-, multisyllabic; and similar words, of which the positive already expresses the only and ultimate degree of quality. Leer, empty, and voll, full, do not belong to this group, as they admit relative comparison: a hall, for instance, may be emptier or fuller than another.

LX. Superlative Formed by Circumlocution. The superlative formed with am is used relatively (comparatively) with predicative adjectives and adverbs: Am besten ist das Brot, wenn es nicht zu frisch ist, The bread is best when it is not too new. Die Kinder sind fleißig, wenn sie allein sind, aber am fleißigsten im Bei'sein des Lehrers; The children are diligent when they are alone, but most diligent in the presence of the teacher.

1. The superlative formed with aufs is generally used adverbially and absolutely, without comparison, thus denoting a very high absolute degree of a certain condition: Ich wurde aufs Beste empfangen, I was received in the best way; ich war aufs Schlimmste gefaßt, I was prepared for the worst; er war aufs Höchste überrascht', He was surprised in the highest degree.

2. Adverbial superlatives with the root-form -st are usual with adjectives ending in -ig and -lich (generally in the *absolute* sense) denoting politeness, devotion, etc.: an'gelegentlich, concernedly, urgently, pressingly, angelegentlich-st; ehr'erbietig, reverentially, ehrerbietig-st; höflich-st, politely, ich bitte höflich-st, I beg most politely; sagen Sie mir gefäl'lig-st, Will you kindly tell me; zeigen Sie mir gütigst, Will you kindly show me, etc. But besides these there are some adverbial superlatives with -st, which are used in a relative sense: Bringen Sie mir möglich-st schnell, Bring me as quickly as possible; sie gab mir die mindest schöne Rose, She gave me the least beautiful rose, etc.

3. The adverbial superlative formed with -ens is generally used in an absolute sense: ich danke Ihnen schönstens (or bestens), I thank you very much; but never ich danke Ihnen herzlichstens, I thank you most heartily, as herz-lich is dissyllabic and belongs to the group of adjectives ending in -lich which take the root-form of the superlative with -st: herzlich-st.

4. Several adverbial superlatives with -st and the prefix zu are used relatively, the latter being sometimes written separately: zu höchst, highest; zu tiefst, lowest; and sometimes contracted with the superlative: zuerst', firstly; zuletzt, lastly; zumeist, mostly.

5. Several adverbs of place have corresponding attributive adjectives, which are used adverbially in the superlative.

Positive Adverb		*Attributive Adjective*		*Superlative Adjective used Adverbially*	
außen	out, on the outside	äußer	outward	äußerst	utmost, extreme
innen	within	inner	inner, intrinsic	innerst	inmost, innermost
oben	above, overhead	ober	upper, higher	oberst	uppermost, highest
unten	below, beneath	unter	under, below	unterst	lowest, undermost
(hie)nieden	down, below	nieder	low, lower	niederst	lowest
hinten	behind	hinter	behind, after	hinterst	hindermost, last
vorn	before, in front	vorder	fore, front	vorderst	foremost
mitten	in the midst, in the middle	mittler (mittel)	middle, mean	mittelst	midst, middlemost

LXI. Irregular Verbs; some combining strong and weak elements, some with irregular inflections.

Infinitive		Present Tense	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
bringen	to bring	ich bring-e, -ſt, -t	ich brachte	ich brächte	bring(e)	gebracht
dünken	to seem, appear	es dünkt	es däuchte	es däuchte	dünke	gedäucht
dürfen	to have permission, may	ich darf, darfſt, darf; wir dürfen, dürft, dürfen; subj.: ich dürfe	ich durfte	ich dürfte	—	gedurft
können	to be able to, can	„ kann, -ſt, kann; wir können, könnt, können; subj.: ich könne	„ konnte	„ könnte	—	gekonnt
mahlen *	to grind	„ mahl-e, -ſt, -t	„ mahlte	„ mahlte	mahl(e)	gemahlen
mögen	to be able, like, wish	„ mag, -ſt, mag; wir mögen, mögt, mögen; subj.: ich möge	„ mochte	„ möchte	—	gemocht
müſſen	to be obliged, must	„ muß, -t, muß; wir müſſen, müßt, müſſen	„ mußte	„ müßte	—	gemußt
ſalzen	to salt	„ ſalz-e, -eſt, -t	„ ſalzte	„ ſalzte	ſalz(e)	geſalzen
ſollen	to be obliged, shall, ought	„ ſoll, -ſt, ſoll; subj.: ich ſolle	„ ſollte	„ ſollte	—	geſollt
ſpalten	to split	„ ſpalt-e, -eſt, -et	„ ſpaltete	„ ſpaltete	ſpalt(e)	geſpalten
wiſſen	to know	„ weiß, -t, weiß; wir wiſſen, wißt; subj.: ich wiſſe, -eſt, -e	„ wußte	„ wüßte	wiſſe	gewußt
wollen	to be willing, will	„ will, -ſt, will; wir wollen, wollt, wollen	„ wollte	„ wollte	wolle	gewollt
denken	to think	„ denk-e, -ſt, -t	„ dachte	„ dächte	denk(e)	gedacht
brennen	to burn, scorch	„ brenn-e, -ſt, -t	„ brannte	„ brennte	brenn(e)	gebrannt
kennen	to know	„ kenn-e, -ſt, -t	„ kannte	„ kennte	kenn(e)	gekannt
nennen	to name	„ nenn-e, -ſt, -t	„ nannte	„ nennte	nenn(e)	genannt
rennen	to run	„ renn-e, -ſt, -t	„ rannte	„ rennte	renn(e)	gerannt
ſenden	to send	„ ſend-e, -eſt, -et	„ ſandte also ſendete	„ ſendete	ſend(e)	geſandt also geſendet
wenden	to turn	„ wend-e, -eſt, -et	ich wandte also wendete	„ wendete	wend(e)	gewandt also gewendet

* Note the difference between mahlen, to grind, and malen, to paint, which follows the weak conjugation.

EXAMINATION PAPER XVI.

1. Which elements are to be found in the conjugation of irregular verbs?
2. How do the verbs brennen, kennen, nennen, rennen form the subjunctive imperfect?
3. How can one form by circumlocution the superlative of predicative adjectives and corresponding adverbs of manner?
4. How is the comparison of inferiority effected?
5. How are the degrees of mutual qualities compared?
6. Why is it possible to use the indefinite article with the comparative, and, as a rule, not with the superlative?
7. Which of the two articles is employed with the superlative, and when must it be dropped?
8. When is it possible to use the indefinite article with the superlative?
9. Which adjectives are not subject to comparison?
10. Which adverbs take the root-form -ſt in the superlative?

Exercise 1. Insert the missing verbs:

Der Müller . . . . . das Korn. Der Künſtler hat
The miller grinds the corn. The artist has
das Bild . . . . . . Haſt du den Kaffee . . . . . . ?
painted the picture. Have you ground the coffee?
Wenn ich nur mit euch gehen . . . . . ! Er . . . .
If I only could go with you! He must
heute gehen. Das Haus . . . . . Der Vater . . . . . .
go to-day. The house burnt. The father bought
die Geſchenke für die Kinder. Warum . . . . . . ihr
the presents for the children. Why did you know
nichts? Ich . . . . nicht ſpielen. Sie
nothing? I was not allowed to play. She
. . . . . . nicht daran. Die Köchin . . . . das Fleiſch.
did not think of it. The cook salted the meat.
Das Fleiſch war nicht . . . . . Er . . . . ihr Blumen.
The meat was not salted. He sent her flowers.
Was hat er ihr . . . . . ?
What has he sent her?

Exercise 2 (*a*). Change the following comparatives into positives and superlatives:

Ich werde lieber zu Ihnen kommen. Es iſt kühler
I shall prefer to come to you It is cooler

im Garten. Er veran'staltete Alles besser.
in the garden. He arranged everything better.
Unsere Pferde liefen schneller. Die Rose roch
Our horses ran faster. The rose smelt
süßer. Er zielte genauer.
more sweetly. He aimed more precisely.

(*b*). Change the following comparatives into superlatives:

Er war ein jüngerer Sohn der Familie. Wir waren
He was a younger son of the family. We were
schlechtere Schüler in unserer Klasse. Ich sitze
worse pupils in our class. I am sitting
unter einem schattigeren Baume. Erzählen Sie uns
under a shadier tree. Tell us
eine lustigere Geschichte. Er heiratet ein
a jollier story. He marries a
reicheres Mädchen.
richer girl.

(*c*). Change the following sentences into the form of the English Possessive:

Der siegreichste Feldzug Napoleons.
The most glorious campaign of Napoleon.
Die schönste Zier des Menschen ist die Beschei'denheit.
The most beautiful adornment of man is modesty.
Das edelste Tier des Waldes ist der Hirsch.
The noblest animal of the forest is the stag.

(*d*). Insert the missing superlative suffixes:

Ich danke Ihnen best. . . . Ich danke Ihnen
I thank you [in the best way]. I thank you
herzlich. . . . . Grüßen Sie ihn schönst. . . .
most heartily. Give him my kindest regards.
Ich empfehle mich ergeben. . . .
I am your most obedient servant
(I recommend myself most obediently).

KEYS TO EXERCISES IN EXAMINATION PAPER XV.
(PAGE 3064)

EXERCISE 1 (*a*). Der Tisch ist breiter. Das Seil ist dicker. Der Wein ist feiner. Die Rose riecht herrlicher. Wir kauften schönere Blumen. Er sah trauriger aus. Der Himmel ist düsterer. Der Baum ist kahler. Das Schloß war loser. Mein Pferd ist edler. Mein Pferd ist von edlerer Abstammung. Er sandte mir einen flinkeren Boten. Ich sah ein schlankeres Mädchen. Die Kerze brannte heller. Mein Papier ist weißer, und Ihres ist gelber. Nettere Leute findet man selten.

(*b*). *Comparative:* Das Pferd läuft schneller. Die Sonne Italiens scheint heller. Ich wohne näher. Der Ton klingt reiner. Das Kind lernt fleißiger. Der Ballon steigt höher.

Superlative: Das Pferd läuft am schnellsten. Die Sonne Italiens scheint am hellsten. Ich wohne am nächsten. Der Ton klingt am reinsten. Das Kind lernt am fleißigsten. Der Ballon steigt am höchsten.

(*c*). Dieses Kind ist das eitelste (or am eitelsten). Die Straße war die ebenste (or am ebensten). Die Gesellschaft war die fröhlichste und heiterste (or am fröhlichsten und heitersten). Der tiefste Brunnen war auch der breiteste (or am breitesten). Man muß am vorsichtigsten sein, wenn etc. Der Turm ist der höchste (am höchsten). Das höchste Haus kostet am meisten. Ich habe das beste Pferd gekauft. Der edelste Wein schmeckt am besten.

(*d*). Ich bin so groß wie du. Ich bin größer als du. Sie sind so liebenswürdig wie Ihre Schwester. Sie sind liebenswürdiger als Ihr Bruder. Dieser Schüler ist weniger fleißig als jener, obgleich er so alt ist wie er. Das Haar des Mädchens war licht wie ein Kornfeld. . . . . lichter als ein Kornfeld.

EXERCISE 2 (*a*). Ich war der Fünfzehnte in der Reihe. Der Offizier las zuerst den dritten Namen und dann den achten. Es war am einundzwanzigsten Mai. Auf welchen Tag der Woche fällt der erste April?

(*b*). Ein halb; ein Drittel; ein Viertel; ein Fünftel; ein Sechstel; ein Siebentel; ein Achtel; ein Sechzehntel; ein Zwanzigstel; ein Dreißigstel; ein Vierzigstel. $1\frac{1}{2}$ $4\frac{1}{2}$, $3\frac{1}{2}$, $5\frac{1}{2}$, $2\frac{1}{2}$.

Continued